Bonriki Inundation Vulnerability Assessment

Project Stakeholder Engagement Activities

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Australian Government

SPC Secretariat of the Pacific Community

Australian Aid

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Original text: English

Secretariat of the Pacific Community Cataloguing-in-publication data

SPC Technical Report SPC00013

February 2015

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This report has been produced with the financial assistance from the Secretariat of the Pacific Community.

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The BIVA project is part of the Australian Government's Pacific-Australia Climate Change Science and Adaptation Planning Program (PACCSAP), within the International Climate Change Adaptation Initiative. The project was developed by the Secretariat of the Pacific Community's (SPC) Geoscience Division (GSD) in partnership with the Australian Government and the Government of Kiribati (GoK).

Key GoK stakeholders that contributed to the implementation of the project were:

- Ministry of Public Works and Utilities (MPWU), in particular the Water Engineering Unit with the MPWU
- The Public Utilities Board (PUB), in particular the Water and Sanitation Division and the Customer Relations Division within the PUB
- The Office of the President, in particular the Disaster Management Office
- The Ministry of Environment, Lands and Agricultural Development (MELAD) Lands Division
- The Ministry of Fisheries and Marine Resources Development (MFMRD) Minerals Division
- Members of the Kiribati National Expert Group on climate change and disaster risk management (KNEG)

The Bonriki Village community members also played a key role in the implementation of the project. Community members participated in the school water science and mapping program, assisted with construction of new piezometers and data collection for the groundwater component, and shared their knowledge and experiences with regards to historical inundation events and coastal processes.

Key technical advisors involved with implementation of the project included:

- Flinders University, Adelaide, Australia
- University of Western Australia, Perth, Australia
- The University of Auckland, Auckland, New Zealand
- United Nations Educational, Scientific and Cultural Organization, Institute for Water Education (UNESCO-IHE), Delft, the Netherlands
- Technical advisors Tony Falkland and Ian White

Glossary

Bwabwai Taro-like plant that is grown in pits that are dug down into groundwater

Mwaneaba Community meeting place

List of Abbreviations

BIVA	Bonriki Inundation Vulnerability Assessment (project)
GoK	Government of Kiribati
GSD	Geoscience Division
KAPII	Kiribati Adaptation Program Phase II
KAPIII	Kiribati Adaptation Program Phase III
KGV & EBS	King George V and Elaine Bernacchi School
KJIP	Kiribati Joint Implementation Plan for Climate Change and Disaster Risk Management
KNEG	Kiribati National Expert Group on Climate Change and Disaster Risk Management
KUC	Kiribati Uniting Church
MELAD	Ministry of Environment, Lands and Agricultural Development
MFMRD	Ministry of Fisheries and Marine Resources Development
MPWU	Ministry of Public Works and Utilities
OB	Office of the President
P3DM	Participatory 3D Mapping
PUB	Public Utilities Board
SPC	Secretariat of the Pacific Community
UAS	Unmanned Aircraft System
WEU	Water Engineering Unit (within the MPWU)

1. Introduction

1.1. Background

The Bonriki Inundation Vulnerability Assessment (BIVA) project is part of the Australian government's Pacific–Australia Climate Change Science and Adaptation Planning Program (PACCSAP), within the International Climate Change Adaptation Initiative. The objectives of PACCSAP are to:

- improve scientific understanding of climate change in the Pacific;
- increase awareness of climate science, impacts and adaptation options; and
- improve adaptation planning to build resilience to climate change impacts.

The BIVA project was developed by the Geoscience Division (GSD) of the Secretariat of the Pacific Community (SPC) in partnership with the Australian government and the Government of Kiribati (GoK).

1.1.1. Project objective and outcomes

The BIVA project aims to improve our understanding of the vulnerability of the Bonriki freshwater reserve to coastal hazards and climate variability and change. Improving our knowledge of risks to this freshwater resource will enable better adaptation planning by the GoK.

More specifically, the project has sought to use this knowledge to support adaptation planning through the following outcomes:

- Improved understanding and ability to model the role of reef systems in the dissipation of ocean surface waves and the generation of longer-period motions that contribute to coastal hazards.
- Improved understanding of freshwater lens systems in atoll environments with respect to seawater overtopping and infiltration, as well as current and future abstraction demands, recharge scenarios and land-use activities.
- Enhanced data to inform a risk-based approach in the design, construction and protection of the Bonriki water reserve.
- Increased knowledge provided to the GoK and the community of the risks associated with the impact of coastal hazards on freshwater resources in response to climate change, variability and sea-level rise.

1.1.2. Context

The Republic of Kiribati is located in the Central Pacific and comprises 33 atolls in three principal island groups. The islands are scattered within an area of about 5 million square kilometres. The BIVA project focuses on the Kiribati National Water Reserve of Bonriki. Bonriki is located on Tarawa atoll within the Gilbert group of islands in Western Kiribati (Figure 1). South Tarawa is the main urban area in Kiribati, with the 2010 census recording 50,182 people of the more than 103,058 total population (KNSO and SPC 2012). Impacts to the Bonriki water resource from climate change, inundation, abstraction and other anthropogenic influences have potential for severe impacts on

people's livelihood of South Tarawa. The Bonriki water reserve is used as the primary raw water supply for the Public Utilities Board (PUB) reticulated water system. PUB water is the source of potable water use by at least 67% of the more than 50,182 people of South Tarawa (KNSO and SPC 2012). Key infrastructure including the PUB Water Treatment Plant and Bonriki International Airport and residential houses are also located on Bonriki, above the freshwater lens, making it an important economic, social and cultural area for the Republic of Kiribati.

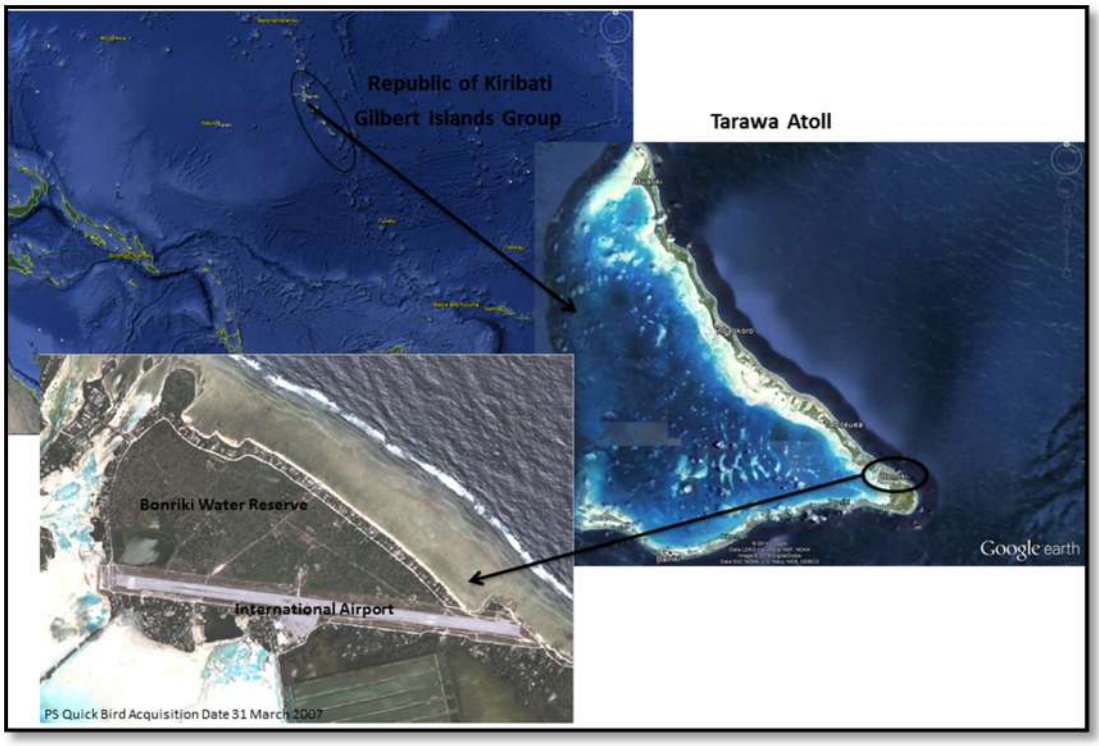


Figure 1. *Bonriki water reserve location*

1.2. Purpose of this report

The purpose of this report is to provide a summary of the stakeholder engagement activities undertaken as part of the BIVA project, and document key lessons learned and outcomes from these activities. As illustrated in Figure 2, the project consisted of three interlinked components: stakeholder engagement, groundwater investigations and analysis, and coastal investigations and analysis. The stakeholder engagement component of the project has both been guided and supported by the technical groundwater and coastal components with information provided by stakeholders to inform the project and vice versa.

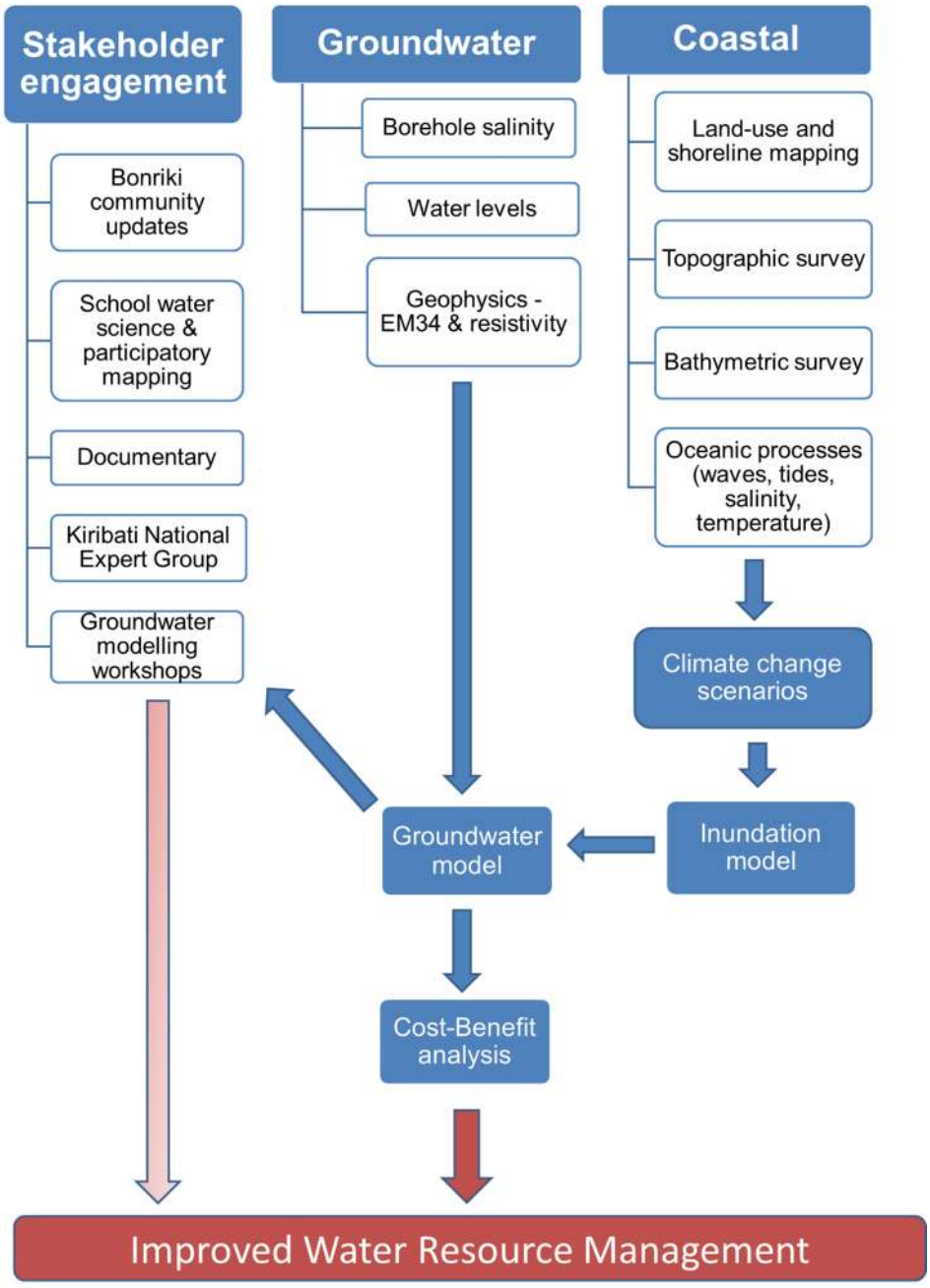


Figure 2. *Bonriki Inundation Vulnerability Assessment project components*

1.3. Scope of this report

The two main stakeholder groups engaged throughout the BIVA project were the Bonriki community and the GoK project implementing partners. This report provides details of the specific activities undertaken with these stakeholders and is structured such that:

- Section 2 provides a stakeholder analysis and captures the lessons learned from community engagement activities undertaken by others working in Bonriki;
- Section 3 outlines the specific engagement activities involving the GoK, including the technical capacity building activities and briefing and reporting of multi-stakeholder groups;

- Section 4 outlines the specific activities undertaken with the broader Bonriki Village community, including the community meetings, project documentary, coastal hazard surveys and involvement with field investigations; and
- Section 5 provides details of the school engagement activities, including programme of the water science and three-dimensional participatory mapping.

This report refers to the investigations and analysis undertaken as part of the groundwater and coastal components but does not seek to replicate the information within these. For detail on data collection and analysis, and processes undertaken as part of these components, refer to the other technical reports.

2. Stakeholder Engagement Planning

2.1. Introduction

2.1.1. Stakeholder engagement purpose

To achieve the project's aims, engagement with the community and government stakeholders was required in order to:

- gain local knowledge regarding geomorphic changes from wave action and inundation events;
- share knowledge and results of the oceanographic and hydrogeological modelling and data collection activities undertaken for the project; and
- increase knowledge and awareness within the community of the hazards to groundwater resources, particularly from land-use activities.

2.1.2. Stakeholder engagement activities

The following activities were undertaken as part of the stakeholder engagement component of the BIVA project:

- Community survey to assess coastal hazard concerns, following the March 2014 inundation event (stakeholder engagement aim 1).
- Progress updates to stakeholder technical advisory body, Kiribati National Expert Group (KNEG) on climate change and disaster risk reduction (stakeholder engagement aim 2).
- Consultation and engagement with key implementation agencies, Ministry of Public Works and Utilities (MPWU) and PUB (stakeholder engagement aim 2).
- Presentation to multi-stakeholder advisory groups on results of technical assessments and management options (stakeholder engagement aim 2).
- Community outreach — community participation in project data collection activities and presentation of technical results to community leaders (stakeholder engagement aims 2 and 3).

- School outreach — groundwater science activities and participatory three-dimensional (3D) mapping activities (P3DM) with Bareumai Primary School students and King George V and Elaine Bernacchi School (KGV & EBS) (stakeholder engagement aims 2 and 3).
- Project documentary on groundwater science, water conservation and the vulnerability of the groundwater lens to impacts from anthropogenic and natural hazards (stakeholder engagement aim 3).

2.1.3. Stakeholder engagement planning

A stakeholder engagement plan was developed at the beginning of the project to outline the activities to be undertaken throughout the project period. As part of this planning process the following activities and analysis were undertaken:

- an analysis of stakeholders' interests in the project, impact of the project on these stakeholders, and stakeholders' expectations for the project;
- a review of current and past engagement activities undertaken with the Bonriki community; and
- a scoping mission to assess the application of participatory mapping techniques to achieve BIVA project community engagement objectives.

2.2. Stakeholder analysis

The stakeholder analysis was undertaken to inform the development of the stakeholder engagement plan. The stakeholders identified in Table 1 have an interest in the BIVA project and can affect or be affected by project activities.

Table 2 summarises stakeholders' interest in the project, impacts of the project on stakeholders, and stakeholders' expectations for the project. These interests have been developed from the point of view of project delivery and management, and the analysis was used as part of the planning exercise for stakeholder engagement activities to be undertaken throughout project implementation.

Table 1. *Summary of project stakeholders — interests and expectations*

Stakeholder	Interests	Expectations and level of engagement
Australian government (PACCSAP programme)	– Funding and visibility – Effective project delivery to the community and other stakeholders. This will support and facilitate access to sustainable livelihoods and means of community's and other stakeholder's protection. – Achieving project outcomes 'addressing high priority adaptation needs in vulnerable countries'.	– Reporting, transparency and accountability. – Informed of project progress and outcomes – Involvement with in-country multi stakeholder briefings.
Geoscience Division of the Secretariat of the Pacific Community	– Improving scientific knowledge, data, modelling resources and equipment for management of Bonriki water resources. – Improving knowledge and capacity of Government of Kiribati (GoK) and local community for climate change adaptation and water resource management. – Improved relationships with key GoK and Bonriki community stakeholders.	– Effective project delivery. – Project delivery that empowers stakeholders and creates a sense of ownership of project products and outcomes.
Ministry of Public Works and Utilities	– Improving scientific knowledge. – Improving knowledge and capacity for climate change adaptation and water resource management. – Improved data, water reserve monitoring capacity and equipment. – Improved understanding from the Bonriki community stakeholders on the function, importance and vulnerability of fresh groundwater resource leading to better cooperation with GoK on water resource management mainly on the water reserve. – Communicating project progress and outputs to broader GoK stakeholders.	– Capacity development for Water Engineering unit staff on groundwater modelling development and analysis. – Data shared. – Regular updates on project progress. – Collaborate and assist with GoK and community engagement activities.
Public Utilities Board	– Improved knowledge of pumping and water reserve management. – Involvement with community engagement activities.	– Kept informed of project outcomes. – Collaborate with engagement activities.
Office of the President and Kiribati National Expert Group on climate change and disaster risk management	– Strengthening strategies and knowledge for climate change adaptation – As for Ministry of Public Works	– Kept informed of project activities and progress

Stakeholder	Interests	Expectations and level of engagement
Other water sector projects	– Sharing of data and findings from investigations, modelling and community engagement activities.	– Capacity development with range of data collection techniques and analysis. – Collaboration and inform.
Bonriki Village committee and community	– Physical and tangible outputs that benefit land management with regards to wave action impacts (erosion) and inundation. – Intangible benefits, including improved understanding and involvement with water resource management context in Bonriki. – Being given an opportunity to input their ideas, experiences and knowledge into the studies. – Economic benefits through opportunities to work with project team and assist with data collection.	– Kept informed and involved with discussions on project activities. – Collaborate and consulted on activities that impact the community. – Assist with data collection. – Educational programme for school.

Table 2. Bonriki community stakeholder analysis — interests, impacts and expectations

Stakeholder	Interest	Impacts	Expectations and level of engagement
Bonriki Village leadership committee and church groups	– Future implications to livelihood (i.e. inundation from climate change, improved water resource management etc.). – Facilitate transfer of information to broader community. – Represent community viewpoints and requests to project team. – Changes to activities and infrastructure on water reserve and land. – Improved water quality and security.	– Improved leadership for water resource management. – Improved understanding of future inundation impacts and options for adaptation. – Engineering and management options for reducing saline incursion risk impact landowners (positive and negative). – May feel threatened by project if there is a perceived tightening of restrictions to activities on water reserve.	– Kept informed and involved with discussions on project activities and outputs. – Consulted and involved with discussions on activities that impact or involve the community.
School students	– Future implications to livelihood. – Education and broader understanding of surrounding environment.	– Improved understanding and educational benefit which enables them to contribute to risk assessment and water resource management for the project. – Develops young leaders who understand the water resource issues in the community. – Time taken up by project activities, impacts time available for other studies.	– Participation, learning and sharing information.
Older youth (above school age)	– Future implications to livelihood. – Changes to activities and infrastructure on water reserve and land.	– May feel threatened by project if there is a perceived tightening of restrictions to activities on water reserve. – Awareness of water resource issues through documentary.	– Included in consultations and discussions.
Women	– Future implications to livelihood and children's livelihood. – Improved water quality and security. – Changes to activities and	– Provide forum to express opinions and ideas and contribution to risk assessment and water resource management awareness activities.	– Kept informed of project activities and outputs. – Included in consultations. – Informed of water

Stakeholder	Interest	Impacts	Expectations and level of engagement
	infrastructure on water reserve and land.	– Awareness of water resource issues through documentary.	resource issues via children involved in school activities.
Gravel and sand miners and Bwabai pit owners	– Changes to activities and infrastructure on water reserve and land. – Improved water quality for crops.	– May feel threatened by project if there is a perceived tightening of restrictions to activities on water reserve and contribution to risk assessment and water resource management activities.	– Kept informed of project activities. – Included in consultations.

2.3. Review of previous community engagement activities

A review of community engagement activities undertaken by other stakeholders working in Bonriki was done to inform the planning of the BIVA community engagement strategy. The stakeholders already working with the Bonriki community and included in this review were the:

- PUB,
- South Tarawa Sanitation Improvement Sector Project (STSISP),
- Aviation Authority, and
- Kiribati Adaptation Program (KAP) (Phase II and Phase III).

The lessons learned and summary of activities undertaken by these stakeholders is provided in Appendix A. Based on the stakeholder analysis and assessment of engagement activities involving the Bonriki community, the following opportunities were identified for engaging the community:

- Adaption of P3DM approach to engage school students at KGV & EBS and Bareaumai Primary School.
- Use of the KAPII resources such as Bingo for the educational activities with the schools.
- Collaborate with PUB plans to engage Bonriki Village via their established committee, and use as a forum for disseminating information and arranging community meetings.
- Use of STSISP resources for educational activities such as the use of puppets.
- Engaging youth entertainers.
- Continuing with the consultation approach undertaken in November 2013, which uses the whole of village committee, mwaneabas and church announcements, and the distribution of fliers and posters as a mechanism to update the community on the progress of the project and its outcomes.

A theme highlighted throughout this review is that past activities have been driven by outsiders to the community. A challenge for the BIVA project was to both overcome this prior experience and foster participation of community members. Although there was opportunity for participation of the community within the project, the BIVA project community engagement scope was focused on

information and knowledge sharing and was designed and driven by outsiders (the project team and government stakeholders). The participatory aspects of this process were undertaken as part of the school engagement activities (described in Section 5) and in the involvement of community members in the field data collection. Despite this, the success of this aspect of the project came from building good relationships with community leaders, Bareaumai Class 3 students, their parents and teachers.

2.4. Participatory mapping scoping mission

A scoping mission to assess the feasibility of using P3DM as a community engagement tool for the BIVA project was undertaken by J.C. Gaillard of the University of Auckland from 28 July to 4 August 2013.

The scoping mission report presented in Appendix B raises the following issues:

- The team was unable to identify strong community representative partners, although suggestions included churches, primary school and women groups.
- Government policy of declared water reserve conflicts with traditional land-use activities (including graves, gravel mining and bwabai pits) and recent moves for eviction by the Attorney General are increasing tensions between government stakeholders and local village residents.
- SMEC are already undertaking a similar community engagement project that may duplicate efforts with potentially the same community partners.
- There is not sufficient connection with the community and building the required rapport to undertake the P3DM will require a long term approach.

The following opportunities and recommendations made within the P3DM scoping report (Appendix B) are relevant to planning community engagement activities for the BIVA project:

- The local primary school could provide a good entry point into the community. Activities that could be conducted include involving students in the running of a social survey to gather preliminary data for water and climate monitoring, or integrating project awareness activities into regular science curriculum.
- The PUB, in collaboration with the WEU, could be a good partner for running engagement activities.
- P3DM would offer the opportunity to discuss water and inundation-related issues with a tangible and commonly trusted tool with locals and could be used to demonstrate hydrogeological processes and map land-use activities.

3. Government of Kiribati stakeholder engagement

3.1. Introduction

The BIVA project management structure is illustrated in Figure 3. The Office of the Beretitenti (President), OB, is the lead agency, while the MPWU is the key implementing agency and the PMU sits within the Water Engineering Unit (WEU) of the MPWU and reports directly to the MPWU Permanent Secretary and head of the WEU. Consultation and engagement with key implementation agencies, MPWU and PUB, including providing regular progress updates via teleconference and participation in the technical advisory group meeting at Flinders University in Adelaide, Australia for deciding on key modelling scenarios.

The KNEG is an advisory body with representatives from government ministries and non-governmental organisations. KNEG was formed in order to develop the 2014 Kiribati Joint Implementation Plan (KJIP) on climate change and disaster risk management, and was considered the most appropriate multi-stakeholder body for the BIVA project to report to. The KJIP sets out actions and costs to address climate change impacts and support disaster risk management.

Over the course of the project's implementation, a series of meetings were held with GoK counterparts and stakeholders to advise them of the progress and development of the project at key milestones and where their guidance was sought. In addition, other GoK agencies have been involved in a technical capacity to assist and learn new techniques during the data collection phase and with community engagement activities.

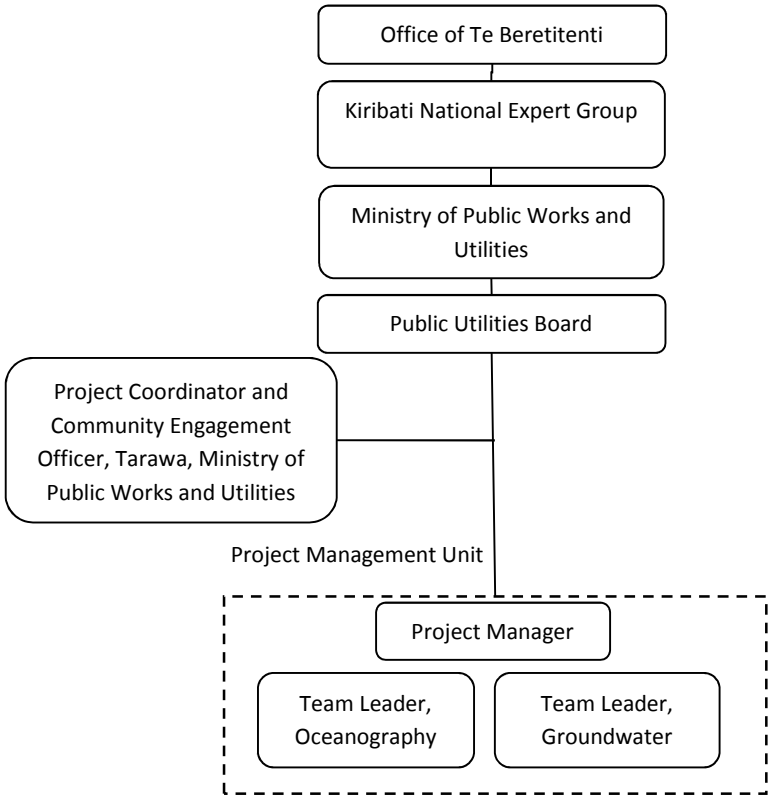


Figure 3. Project management structure

3.2. Capacity building activities

3.2.1. Survey methods

As part of the project's data collection phase, a number of GoK staff were involved with the topographic and bathymetric surveys. Staff were from the Ministry of Environment, Lands and Agricultural Development (MELAD) Lands Division, Ministry of Fisheries and Marine Resources Development (MFMRD) Minerals Division, and MPWU WEU. These staff members were trained in the use of Trimble GPS systems Real-Time Kinemetic (RTK) survey methods, and this training included two days of theory and three weeks of field survey. The field surveys involved learning the basics and setting up of RTK, and differing survey techniques were also practised. Software such as TBC and Quantum GIS were then used to show field data download and processing.

After completion of this training, the Lands and Minerals Divisions were able to initiate RTK surveys as part of their respective programme projects. One such project is coastline monitoring of Tarawa, where the shoreline is being repeatedly surveyed from Betio to Bonriki.

As part of the topographic survey of Bonriki, SPC was able to purchase and trial the latest TRIMBLE Unmanned Aircraft System (UAS) system, the TRIMBLE UX5. One representative from MELAD Lands Division was able to attend the one-week training on the surveying and processing components of the UAS. The GoK is considering purchasing this type of system and this provided a unique opportunity to use and evaluate the method prior to purchasing this equipment.

Figure 4. *Setting up a base station at one of the benchmarks*

Figure 5. *Trimble R8 was mounted on the quad bike to assist with RTK survey coverage on the sand flats as well as the water reserve*

Figure 6. *A canoe was used for an RTK survey in the lakes and saltwater marshes*

Figure 7. *Launching ramp for UAS TRIMBLE UX5*

3.2.2. Groundwater survey

MPWU WEU staff were involved in the data collection for the project's groundwater component. This included using methods that staff were familiar with, such as the EM34 geophysics survey, and monitoring of electrical conductivity in groundwater using multi-level boreholes. It also included training in resistivity survey methodology, which was a new geophysics survey method to WEU staff. These surveys were conducted with the assistance of Bonriki community members (as described in Section 4.6).

Figure 8. *Water Engineeering Unit (WEU) staff discussing resistivity survey methodology (left) and WEU staff undertaking EM34 survey work (right)*

3.2.3. Groundwater modelling training

Groundwater modelling training was held at the MPWU boardroom on 2–3 December 2014. This training was facilitated by staff from Flinders University in response to the GoK's request that some technical support be provided to understand and interpret the numerical modelling component of the project. There were 12 attendees from WEU and PUB, and the training included:

- theory on basic hydrology, groundwater movement and associated governing equations;
- a demonstration of atoll hydrology using a physical model;

- an introduction to numerical groundwater modelling, including guidelines and reasons for modelling and a hands-on model construction exercise; and
- a demonstration of the BIVA numerical model, including how the model was constructed, assumptions made, results and discussion on its application in the future.

Figure 9. *Physical model of atoll hydrogeology used for demonstration during workshop (left). Workshop attendees developing simple groundwater model (right)*

3.3. The Government of Kiribati's involvement with community engagement activities

The WEU and PUB assisted with facilitating school educational activities, including class work and field work, and provided a facilitation role during P3DM activities. The PUB and WEU also provided an integral role in the development of the project documentary, ensuring messages were aligned with GoK priorities; the final product remains relevant for use by PUB and WEU after completion of the BIVA project.

Figure 10. *Water Engineering Unit staff assisted with class work and field work related to the water reserve borehole monitoring programme conducted by the Ministry of Public Works and Utilities*


Figure 11. *The Public Utilities Board provided a tour of its facilities*

3.4. Kiribati National Expert Group project updates

The KNEG is an advisory body with representatives from government ministries and non-governmental organisations. As discussed in Section 3.1, KNEG was considered to be the most appropriate multi-stakeholder body for the BIVA project to report to due to its mandate to consider national actions to address climate change impacts and support disaster risk management.

KNEG was provided with updates on the BIVA project progress at two briefing sessions during the project's implementation. This included a session in August 2014 following the completion of data collection activities and community engagement school activities, and in December 2014 at the completion of the project. Informal updates on the project's progress were also provided by WEU staff during other KNEG meetings, which fell outside the period where BIVA PMU staff were in-country.

In the August session, KNEG members were given a summary of the project's objectives and were provided information on data collection activities and the involvement of the Bonriki community. In the December briefing, members were provided a brief summary of the outcomes of the preliminary findings from the numerical groundwater modelling, and key discussion points raised during more detailed technical briefing workshop held at MPWU with technical stakeholders.

3.5. End of project technical stakeholder briefing

An end of project technical briefing was held on 5 December 2014 for the broad GoK stakeholder group. Participants for this workshop included members from WEU, PUB, MELAD, MFMRD, OB, KAP and STSISP. This workshop coincided with the sitting of Parliament, and hence many senior staff were, unfortunately, unavailable to attend. To overcome this, a separate briefing was provided to senior staff in the MPWU, including the Permanent Secretary, and a one-on-one briefing on the outcomes of the groundwater modelling was provided to the Head of the WEU.

This briefing was a full-day session, covering all aspects of the project, including a:

- presentation of the project documentary and summary of project stakeholder engagement activities;
- summary of field investigations (coastal and groundwater);
- summary of coastal modelling processes and outcomes;

- summary of groundwater modelling processes and outcomes; and
- discussion on the 'way forward'.

After the discussion on the way forward, questions were posed to participants regarding how the BIVA project findings may be used for prioritising government activities and directions and for operational activities, and also what additional questions or scenarios should be considered. Some participant responses included:

- Can salinity be reduced by reducing pumping in key galleries?
- Results can be used to finalise the drought methodology.
- Can the aquifer be artificially replenished? If so, where would the water come from?
- Findings highlight impacts during dry periods and under high abstraction. GoK will consider alternative sources (what information does GoK need with regard to volumes of alternative water required and when).
- Work can inform the water reserve task force to consider impacts of population growth.
- Does removing vegetation affect recharge? (It is likely to increase recharge during a dry season, but would not make much difference during a wet season.)
- What about artificial islands or an extension of land to increase catchment?
- Can the discharge be controlled (i.e. loss to the sea)?
- Want to understand the sustainable pumping options.
- Recommend that findings be made available to a wider audience.
- Use of the drought policy to consider restrictions to pumping and water quality. Use of the drought committee to further discuss the concept of sustainable yield.

4. Bonriki Village community engagement

4.1. Introduction

4.1.1. Purpose

Bonriki community members are an important stakeholder group for the BIVA project. The objective of engaging the community was to:

- gain local knowledge regarding geomorphic changes from wave action and inundation events;
- share knowledge and results of the oceanographic and hydrogeological modelling and data collection activities undertaken for the project; and
- increase knowledge and awareness within the community of the hazards to groundwater resources, particularly from land-use activities.

4.1.2. Approach

The Bonriki community was engaged at different levels in a range of activities. Throughout the planning of these activities, community leaders were consulted via the Whole of Bonriki[1] Village committee or the committee chairperson. The different levels of community involvement with the project included:

- community leaders through the Whole of Bonriki Village committee;
- primary school students and their families, through Bareaumai Primary School water science activities;
- general community members through mwaneaba meetings, surveys and the documentary production and viewing; and
- male youth through their role in assisting with the groundwater survey data collection, and their role as security for oceanographic equipment installed on the reef.

4.2. Bareaumai Primary School engagement activities

Bareaumai Primary School is the only school located in Bonriki Village. As part of the BIVA community engagement programme and as identified in the P3DM scoping mission (refer to Section 2.4 and Appendix B), the school provides a good entry point into the community and an opportunity to integrate water resource management activities into the school curriculum. The activities undertaken with the school are described in detail in Section 5, and included:

- A field trip to Bonriki water reserve facilities, including the PUB water treatment plant, infiltration gallery pump stations, and MPWU monitoring boreholes;
- groundwater science lessons and activities;
- construction of a groundwater model; and
- P3DM of Bonriki Village.

4.3. Project documentary

A documentary style video was produced as a tool to increase knowledge and awareness within the community of the hazards to groundwater resources, and to increase community awareness of and engagement with the BIVA project. The documentary was developed in close collaboration with the WEU and PUB to ensure its relevance for stakeholders after the completion of the project. The intention is that the video will be used as an education resource by WEU and PUB as part of their broader community engagement activities in South Tarawa in the future.

Key themes and topics covered in the documentary include:

- water cycle and climate change;
- groundwater and Kiribati;

[1] The Whole of Bonriki refers to the entire community located around the fringes of the Bonriki water reserve. This community is made up of a number of sub-communities centred around village meeting places (mwaneabas). The Whole of Bonriki community is coordinated through an elected committee, with a chairperson and other executive members of the committee providing a formal point of contact. This committee is convened outside of the Government of Kiribati formal structures, which separately have an elected local government Councillor and Members of Parliament.

- different water sources in South Tarawa;
- South Tarawa PUB water supply system (design, management and threats);
- inundation threat and other water resource issues;
- what can the government and community do; and
- an overview of the BIVA project, including the technical and investigative aspects of the project and school groundwater science activities of the BIVA project.

The video is in I-Kiribati with English subtitles and runs for 30 minutes. An abridged (five- minute) English version of the video was also produced to provide a resource for project visibility and awareness to development partners.

4.4. Bonriki Village community meetings

The mechanism used for updating and informing the community about project progress or activities was via mwaneaba meetings. Meetings held throughout the project are described next.

4.4.1. Mwaneaba meetings for project introduction

Community meetings were held from 5 November to 11 November 2013 to introduce the Bonriki community to the BIVA project, and inform them of the planned installation of oceanographic monitoring equipment on the Bonriki reef flat. The primary objective of these meetings was to develop awareness within the community of the project and of the equipment being installed so to reduce the likelihood of vandalism.

The following specific activities were undertaken:

- Posters and fliers were provided at each community meeting, which described the project and the planned installation of the equipment in I-Kiribati (refer to Appendix C).
- Presentation to Bareaumai Primary School students (355 students enrolled) (Figure 12).
- Presentation on project and equipment installation and a question-and-answer session at small community mwaneabas; Arobati 1, Arobati 2, Arobati 3, Ngeaba, Tokarake (Figure).
- House-to-house visits in the small community on the lagoon side, near Kourabi mwaneaba.
- Large meeting with Whole of Bonriki community at Te Utu ae e tabu mwaneaba to discuss engaging Bonriki community members as security guards for equipment and labourers for piezometer installation.
- Announcements provided to be read out at church services (and Bingo).
- Inform Bonriki police station of equipment installation and community meetings being undertaken.

Figure 12. *Bareaumai Primary School briefing, November 2013*

Figure 13. *Community meeting in Bonriki, November 2013*

The following information and observations are relevant to planning future community engagement activities within the Bonriki community:

- Bonriki Village has a formal leadership structure that is separate from the urban council, and has an elected chairperson and committee. In addition to the leadership group there are 499 households that pay (AU$11/household) to be members of the community group. Membership of the community group allows for input into decisions (such as election of security guard and labourers) and involvement in any activities that require community input. Understanding this community structure allowed community meetings to access the Whole of Bonriki community. In particular, this meant that both women and men attended the larger meeting. This could provide an important entry point for future meetings and this forum is suitable for activities that focus on informing the community.
- Each small village mwaneaba had a different structure or approach to the meetings. Three out of five meetings were attended predominantly by men, while one (Arobati 2) was attended mainly by women and one (Ngeabwa) had an even gender representation.
- Several communities advised that announcements via churches would enable broader stakeholder groups (e.g. youth) to be informed.
- The fliers in I-Kiribati were very well received and provided a good level of information for the purpose of the meetings. Similar posters with images and maps would be useful for future project updates.

- The community was generally interested and supportive of the project and some members expressed a sense of ownership given that the project is focused on Bonriki.
- For mwaneaba consultations:
    - Consultations should be less than one hour because community members will lose interest after this.
    - Find out when community meetings are held and request permission to join the meetings. Make sure that the community's availability is clear and always follow up and confirm community participation.
    - Avoid mwaneaba consultations on Fridays because attendance on that day is typically low.
    - It is best that no mwaneaba fee is provided, and best not to mention this to the community or it will be expected.
    - Emphasise to the community that the project is being implemented for them so that they feel a sense of ownership. Also highlight that they are a part of the project implementation process through various activities.
    - Always involve the Whole of Bonriki chairperson in every mwaneaba consultation. The chairperson has been selected by the Whole of Bonriki community and represents the cross section of the community, including faith-based groups, and women's and youth groups.

Meeting notes are presented in Appendix C.

4.4.2. Presentation of inundation modelling results

On 9 December 2014 a meeting was held with Bonriki community members at the Bonriki Kiribati Uniting Church (KUC) mwaneaba (Figure 4). Members attending the meeting included community leaders and family of the Bareaumai Class 3 students involved with the water science programme. The purpose of this meeting was to present the results of the coastal numerical modelling to the community. Although the inundation extent maps presented during this meeting were alarming for those whose houses are shown to be impacted, it was emphasised that the maps represent rare events that have a low probability of occurring. It was also explained that there is uncertainty with predictions of future sea-level conditions and, therefore, moderate, severe and extreme sea-level scenarios were presented.

Questions raised by participants during the meeting included whether:

- sea-level rise would have a big impact on their lives;
- there was anything that households could be doing to protect the water in their area; and
- PUB abstraction of water is too much and will impact Bonriki household wells.

The questions related to the operation of the PUB water system and abstraction from the Bonriki water reserve provided an opportunity to explain to attendees about the design of PUB infiltration galleries, through the use of diagrams used as part of the school water science activities. This discussion on protecting water resources was also reinforced in the messages within the project documentary. Inundation maps and tidal and swell data from the March event presented during this meeting are included in Appendix D.

Figure 14. *Presentation of inundation mapping results to community members*

4.4.3. Documentary launch

As described in Section 4.2 a 30-minute, documentary style video was developed as an engagement and awareness raising tool. The product was developed in close collaboration with the PUB and MPWU to ensure its relevance for their use in broader awareness raising initiatives after the project.

The project documentary was launched as part of the meeting held at the Bonriki KUC mwaneaba on 9 December 2014 (Figure 15). The documentary was presented to Bonriki community leaders, Class 3 students from Bareaumai Primary School, their families and teachers. As part of the launching activities, BIVA staff also presented the results of the inundation modelling (refer to Section 4.4.2) and a groundwater science quiz was undertaken with the students.

Figure 15. *Documentary launch at Kiribati Uniting Church mwaneaba in Bonriki*

4.5. Coastal hazard surveys

4.5.1. January high tide event survey

On 31 January 2014 a king tide occurred that was predicted to be the highest tide of 2014 (BoM 2014). The tide resulted in inundation and erosion in Bonriki, which was captured through a survey and discussions with community members following the event. Details and photographs from the survey are presented in Appendix E1.

4.5.2. March survey following inundation event

From 1–3 March 2014 there were a number of inundation events that impacted households in Bonriki. This event was caused by the highest tide on record, measured at approximately 2.7 m on 1 March 2014, and a large swell event on 3 March 2014 that coincided with a high tide.

Following the inundation event, members of the BIVA team visited the community to discuss the impact and collect data for calibration of the numerical inundation model being developed by the coastal modelling team. The data that was collected included the depth of the water and the distance inland of the inundation. Appendix E2 provides a summary of the information collected during the survey. The data collected provided valuable information for the calibration of the numerical inundation model, which has been used to generate inundation extent maps for the March 2014 event along with a range of inundation events under different sea-level rise projections, and tide and swell combinations.

4.6. Field investigations and data collection

In November 2013, Bonriki Village community members assisted with the construction of new piezometers (Figure 16) and provided security for the oceanographic instruments that were installed on the reef flat during low tide periods. Community members were selected to provide these services via the Whole of Bonriki committee, and the selection followed the community meeting described in Section 4.4.1.

Figure 16. *Community members assisting with the construction of piezometers on the Bonriki water reserve*

In March, community members assisted with groundwater surveys, including the resistivity and EM34 geophysics surveys. Community members worked with WEU staff and members of the BIVA project team.

Figure 17. Community members assisting with resistivity geophysics survey on the Bonriki water reserve.

5. Bareaumai Primary School engagement activities

5.1. Introduction

5.1.1. Purpose

Engagement with younger members of the Bonriki community was an important component of the BIVA project community engagement activities. The interaction with school students provides a good entry point into the broader community, and the potential to develop knowledge and awareness in both young leaders in the community, but also indirectly in their peers, family and broader community networks. The specific objectives of the school engagement activities were to develop the student group's understanding of:

- groundwater systems,
- how the Bonriki water reserve operates and how the water resource is managed, and
- links between groundwater systems and land-use activities.

The P3DM exercise also aimed to capture local knowledge about the groundwater system and land-use activities in Bonriki to inform the technical investigations and analysis being undertaken as part of the broader project.

5.1.2. Approach

Originally, two schools were identified for the school engagement activities, Bareaumai Primary School and KGV & EBS. However, due to the limited time available for the secondary school students to commit to the activities, the programme primarily focused on the Bareaumai Primary School[2].

Class 3 level students from Bareaumai Primary School were targeted because they had an existing topic on water within their environmental studies unit. BIVA project activities were designed to align

[2] Some water science activities were conducted with the KGV & EBS students over a two-week period. However, they were not available to participate in the mapping activities due to exams and other study commitments. Planning the activities with teachers before the school year began would have enabled better integration of the programme with the secondary school curriculum.

with the existing school curriculum and a number of meetings were held with teachers and the National Curriculum Development Officer to ensure that the activities meshed with the water topic and were suitable for the Class 3 level. The participation of the teachers in the design of the programme and activities was important for their ongoing engagement, professional development and to enable two teachers to be lead facilitators in the activities.

5.1.3. Participatory three-dimensional mapping

P3DM activities were conducted to engage students and the wider Bonriki community. A P3DM advisor, Katherine Hore, from Auckland University guided this process. P3DM is a tool that is increasingly being used in an array of applications by development workers in areas such as resource management, territorial conflicts, climate change adaptation, and disaster risk reduction (Cadag and Gaillard 2012). It consists of constructing a large, stand-alone, scaled three-dimensional map. Layers of georeferenced information can then be depicted on the map using pushpins, yarns and paint. Because the map is scaled and georeferenced, the information depicted can be both local and scientific (Gaillard and Cadag 2013). P3DM, therefore, gives stakeholders a common platform to integrate their knowledge, information and ideas. Through dialogue and collaboration between participating stakeholders, new ideas and information can also be created. P3DM is a useful communication, research and planning tool (Banaynal and Dwamena 2011).

By making different forms of information visible and tangible to everyone involved, P3DM assists people in deciphering, assimilating and comprehending different aspects of dynamic and intangible issues (Gaillard and Cadag 2013). People get a 'birds-eye view' of their environment, enhancing their analytical skills, broadening perspectives of interlocked systems, and enhancing awareness of local territories (Rambaldi and Callosa-Tarr 2002).

5.2. Summary of activities

5.2.1. Water science activities

Water science activities were held in term 2 for a five-week period starting in week 7 (Monday, 30 June 2014) until week 12 (30 July 2014). These were facilitated by BIVA staff with assistance from the WEU and PUB. Experiments, discussions and exercises were carried out to improve the students' understanding of groundwater science before the mapping activities. The water science activities provided the students with the background knowledge required for the P3DM mapping exercise.

Specific activities that were undertaken included:

- Field trip — Students visited the PUB water treatment plant in Bonriki, along with the infiltration gallery pump stations and the MPWU monitoring boreholes. The tour was led by the PUB with assistance from the WEU, Class 3 teachers and BIVA project team. The purpose of the visit was to demonstrate the PUB water supply system to students, including the process of abstraction, treatment and reticulation. This was a good opportunity for community members who live on and around this facility to develop a better appreciation for its operation and purpose. (Figure 18)

- Experiments — These were undertaken to develop students' understanding of groundwater systems. Activities involving groundwater science are as follows, and the handbook developed as a teaching resource is provided in Appendix F:
  - Building a model aquifer to demonstrate how an aquifer is formed with different soil types and geology.
  - Demonstrating the water cycle using the constructed aquifer and, with the aid of the water cycle poster, the elements of the water cycle and their impact on groundwater levels.
  - Demonstrating the interaction between groundwater and surface water, using the constructed aquifer to show the changes in the water table level with inputs from surface water or the movement of tides.
  - Pumping groundwater to demonstrate the impact of abstraction on groundwater and issues with overpumping.
  - Demonstrating the impact of land-use activities on the groundwater system quality.
  - Demonstrate the design of PUB abstraction systems (infiltration galleries) in Bonriki and the interaction of saltwater and freshwater, and the formation of the freshwater lens in a coral atoll[3].
- Using games and quizzes. Resources were drawn on from the KAPII community engagement programme and the existing curriculum material. The interactive nature of these activities enabled teachers to assess students on their learning, and reinforced lessons learned using the model aquifer experiment. The following activities were undertaken for this component:
  - Playing water reserve bingo. This was based on KAPII materials and encouraged students to make a decision about which of the activities shown on cards could occur on or outside the water reserve boundary. The aim of this activity was to build awareness about the potential impact of land-use activities on groundwater. Students were very keen to demonstrate this activity to their families during the closing ceremony day.
  - Water cycle quiz. Students' knowledge on the elements of the water cycle were tested through a group quiz.
  - A final quiz was given to test students' knowledge at the end of the school year, and coinciding with the launch of the BIVA documentary a group quiz covering all topics within the educational programme was undertaken, with prizes awarded as incentives.

[3] The pumping aspect of this activity was unsuccessful due to the weak pump strength and significant density difference between the water and cordial. Testing and modification of this experiment using different equipment and materials is advised prior to running.

Figure 18. *Bonriki treatment plant field visit*

Figure 19. *Building an aquifer. Students had finished building their own aquifer by using container, gravel and sand, coloured water and vegetation*

Figure 20. *Groundwater and surface water: Students pouring water over their aquifer to simulate rain while at the same time pumping*

Figure 21. *Students playing water reserve bingo*

5.2.2. Model of groundwater

To link the learnings from the model aquifer experiments and the P3DM of the Bonriki community, students also constructed a layered map of the groundwater system. As illustrated in Figure , four layers were constructed at the water table (0 m), and at 6 m, 12 m and 18 m below the water table. Students used paint to reflect the different salinity contours. The contours were produced based on physical data collected from MPWU boreholes and geophysics surveys conducted as part of the BIVA project. The purpose of this exercise was to demonstrate the shape of the freshwater lens at different depths, and students were able to correspond this horizontal cross-sectional view with the vertical cross-sectional view taught during the lessons leading up to this activity. As shown in Figure 23., students indicated the amount of fresh, brackish or saltwater at each depth, and demonstrated their understanding of the system when presenting this to their families during the closing ceremony activities.

Figure 22. *Model of salinity contours at 0 m, 6 m, 12 m, and 18 m under Bonriki, produced by students from Bareaumai Primary School, 25 July 2014*

Figure 23. *Model of salinity contours showing annotations by students indicating freshwater 'te mam', brackish water or saltwater at each depth*

5.2.3. Participatory 3D mapping activities

Participatory mapping activities were held from 20 to 25 July with Bareaumai Class 3 students. The activities were intended to help students gain a better understanding of groundwater and how important it is as a resource to be protected, and to increase their awareness of the environment where they live and threats to the water resource. In addition, the process also provided students

with an opportunity to contribute their unique knowledge to the discussion around water resource management in Bonriki. It was also intended that participation be extended to the wider Bonriki community by inviting family members and community leaders on the final day of the activities, as part of the closing ceremony.

Students constructed a base map made from polystyrene and paper mache. Elevations were added using contour lines of 1 m elevation. Simultaneously, a model of the underground water lens was created, by painting salinity contours of a horizontal transect at 0 m, 6 m, 12 m and 18 m (Figure 22).

The children then produced a participatory Venn diagram about water in their daily lives and water-related issues. These issues were then sorted and prioritised using scoring and ranking activities (Figure 24 and Figure 25). The students identified the need to boil water, and this issue was discussed further using a problem tree to explore the reasons this was necessary. From the issues discussed, the relevant information to plot on the map was decided on.

Figure 24. *A Venn diagram depicting daily water uses and water-related issues, 23 July 2014*

Figure 25. *Scoring and ranking activity to prioritise daily uses of water and water-related issues, 23 July 2014*

Following this, activities were run to help the children orient themselves and their surroundings on the blank model. Students were asked to build a sketch model of their community, which they

shared and compared to the aerial photograph and the blank model. A game was played to familiarise students with the scale because they were not used to expressing distances in meters.

Students then painted the features of the surface of the map, including the ocean, reef, lagoon, and the runway (Figure 26). They then discussed plotted key features of their house and their neighbours based on the previous activities described above (Figure 27). This process was guided by aerial photograph of Bonriki.

Figure 26. *Students painting land-use activities and features on a blank model of Bonriki, 24 July 2014 (Photo: Katherine Hore)*

Figure 27. *Students plotting features of their community on the three-dimensional map, 24 July 2014 (Photo: Katherine Hore)*

Figure 28. *Students discussing the map with their family members, 25 July 2014 (Photo: Katherine Hore)*

On Friday, 25 July, the children invited their parents to demonstrate what they had learned (Figure 28). A closing ceremony was held and the students were presented with certificates for completing the programme. Following formal proceedings, the children took family members around the different activities they had undertaken and explained what they had learned, incorporating what they had learned from scientific experiments that were undertaken prior to the mapping activities around the water cycle. Family members were then invited to add to the map, and students also made adjustments based on these discussions. During the closing ceremony, the PUB also presented a number of puppet shows. The shows were developed specifically for the event, and focussed on topics such as water conservation and protection of PUB assets. Puppets and equipment were provided by the STSISP.

5.3. Outcomes

The activities were designed to provide students with not only a broad understanding of groundwater systems, but also a specific knowledge and awareness of the Bonriki system. This was important given the national significance of this water resource to South Tarawa, and the important role the local community that lives on and around the reserve play in its management and protection. Through the collaboration with the Curriculum Development Division, resources have been produced that can be used in the future, and the involvement of the WEU and PUB staff developed their knowledge and confidence in delivering the programme.

For the water science activities, it was satisfying to see that students were confident in sharing with and demonstrating to their families and peers what they had learned. One parent commented that her daughter had been teaching her about infiltration galleries and the groundwater table, and this is the precise kind of outcome that the programme hoped to achieve. For the P3DM exercise, students initially had difficulty reconciling their perceptions of their environment with the scale and orientation of the map. However, over time they demonstrated an increase in spatial awareness and a broadened perspective of their environment, through which they potentially discuss water-related issues.

Students also demonstrated an understanding of the underground model, which they were able to confidently relay to their teachers and parents. Furthermore, they were able to link the purpose of

the boreholes and infiltration galleries scattered throughout their community to this new understanding, increasing their awareness of water issues and monitoring both within and beyond the BIVA project.

The extension of this increased knowledge and educational benefit to the wider community was possible through the invitation of family members and community leaders for the closing ceremony. However, this was limited to relatives of Class 3 students. Attempts to involve the community beyond this via mwaneaba meetings in the week following the mapping exercises proved unsuccessful due to a lack of attendance. This is possibly attributable to a lack of awareness of the planned activities, timing of the event (during the week day) and poor communication to the broader community via the Whole of Bonriki committee members.

6. Conclusions

6.1. Government stakeholder engagement

The focus of engagement with GoK stakeholders was to share knowledge and results of the oceanographic and hydrogeological modelling and data collection activities undertaken for the project. The project has successfully met this objective through the briefing of multi-stakeholder groups, including KNEG, and a strong partnership with the implementing agencies MPWU and PUB. The project has also gone beyond the objective to share knowledge and sought to develop the technical capacity of GoK staff in the areas of:

- topographic and bathymetric survey techniques,
- groundwater geophysics survey methods, and
- numerical groundwater modelling and hydrogeology.

Due to the complex nature of the numerical modelling undertaken as part of both the coastal and groundwater modelling components of the project it was not realistic, within the scope and timeframe available, to fully develop capabilities within GoK in modelling. Instead, the focus of engagement and capacity building in this area was on developing an understanding and ability to critically review and consider the outcomes of the modelling and applications for future management decisions. This was achieved through:

- **Formal training by experienced teaching staff from Flinders University on numerical groundwater modelling and hydrogeology**. The training provided participants with a basic understanding of key concepts of atoll hydrology and numerical modelling. Ultimately, this improved participants' ability to understand and interpret the numerical modelling component of the project and enable more in-depth discussion during the presentation of project results.
- **Ongoing communication, updates and consultation with key technical staff throughout the project**. This included in-country meetings, teleconferences and the attendance of PUB and WEU staff to a Technical Advisory Group meeting held in Adelaide at Flinders University at a key decision point in the numerical modelling process.

6.2. Bonriki community engagement

The objectives of engaging Bonriki community members were to:

- gain local knowledge regarding geomorphic changes from wave action and inundation events;
- share knowledge and results of the oceanographic and hydrogeological modelling and data collection activities undertaken for the project; and
- increase knowledge and awareness within the community of the hazards to groundwater resources, particularly from land-use activities.

During the implementation the project there were two significant king tide inundation events, including the highest tide measured in over 20 years. Following these inundation events, surveys were conducted and through the information and assistance of community members, the data collected provided valuable information for the calibration of the numerical inundation model.

The project has also contributed towards the development of knowledge and awareness in the community on groundwater resource management with a particular focus on the importance of the Bonriki Water Reserve and the PUB water supply assets. This awareness has been developed directly through community participation in the field investigations and data collection component of the project, and through a range of presentations including at community mwaneaba meetings and the educational documentary style video. Indirectly, awareness has been raised through the participation of the Bareaumai Primary School Class 3 students in the BIVA water science program. The interaction with school students provided a good entry point into the broader community, and the potential to develop knowledge and awareness in both young leaders in the community but also indirectly in their peers, family and broader community networks.

6.3. School activities

The objectives of the school engagement activities were to develop the student group's understanding on groundwater systems, how the Bonriki water reserve operates and is managed, and links between groundwater systems and land-use activities. This was successfully achieved through a seven-week programme involving:

- a field trip to the PUB and MPWU water supply and water resource monitoring assets located on the Bonriki water reserve;
- a range of groundwater science educational activities to develop students' understanding of groundwater systems in the context of Kiribati and atoll hydrology;
- the development of a model of the Bonriki groundwater system at different depths to highlight the shape and availability of freshwater across the horizontal and vertical profile; and
- the construction of a three-dimensional model of Bonriki to illustrate land use, water resource management assets and to capture local knowledge about the groundwater system and land-use activities.

Among the activities that were carried out, the week-long intensive programme for the P3DM was well received by students. The format was different from their normal classroom routines, and

although the activity went for five days the students maintained their energy and individual participation was observed to increase as their confidence grew. The teachers indicated that the attendance to the classes, field trip and mapping exercises was much greater than for normal class activities, indicating an enthusiasm for the programme. Based on the observations of the programme facilitators and comments made by students, the students felt a strong sense of ownership to the BIVA project because they could relate the activities to their own environment. The students were proud of the final mapping output, and happy to show it off to other students at the school and their families and friends.

The P3DM activities also appeared to be successful in engaging the children in issues around water management. They were enjoyable for the students, who were motivated to learn and discuss water issues in their community. It was concluded through observation and feedback from teachers and family members that the P3DM activities resulted in improvement in the students' understanding of their environment, the groundwater system, threats to groundwater resources and how they are distributed throughout the community.

This momentum presents an opportunity to foster this interest and increase in knowledge and the awareness with the Class 3 students in Bareaumai Primary School, as well as other years and schools in Tarawa. This could enable students to contribute to risk assessment and water resource management for future water management initiatives.

7. Recommendations

7.1. Government multi-stakeholder engagement

KNEG was identified as the most appropriate multi-stakeholder body for the BIVA project to report to due to its mandate to consider climate change adaptation and disaster risk management planning. The briefings provided to KNEG were intended as a reporting mechanism to a broad and high level GoK audience. However, the BIVA project had difficulty in fully utilising and engaging with this group. This was possibly due to the commitments and pressures on KNEG from other projects or initiatives, and also the observed inconsistency in individual members attending the meetings, which resulted in a lack of continuity and understanding of the project between briefings. This difficulty was circumvented through a separately initiated multi-stakeholder technical briefing at the end of the project, and through more direct collaboration and information exchange with the core implementing agencies MPWU and PUB. Despite this, it is recommended that endeavours to engage sector coordinating bodies such as KNEG form an integral part of any future projects. Government-driven sector coordination is essential to enabling ownership of project activities and outcomes, alignment with government objectives, and ensuring that there is collaboration across projects and development initiatives.

7.2. Community engagement and participatory approaches

A theme highlighted through the early planning stage of the stakeholder engagement activities was that that past activities undertaken in the Bonriki community were driven by outsiders. A challenge for the BIVA project was to both overcome this prior experience and foster participation of

community members. Although an opportunity was created for community participation in the project, the scope was focused primarily on information and knowledge sharing rather than participation.

Given additional resources, a more participatory approach could have been implemented, and would have built on the work undertaken with the school and the networks developed through community member participation in field investigations and data collection. The momentum developed from these activities could have been used to reach out to the broader community and enable them to contribute more fully to the discussion and work being undertaken. Greater time would have allowed for this approach to be trialled and it is recommended that any future initiatives consider how to foster participation throughout project inception, implementation and evaluation phases.

7.3. Participatory 3D mapping

The P3DM aspect of the project was limited in its engagement with the wider community; however, it provides a range of potential future uses within and beyond the BIVA project. Time constraints[4] meant the full potential of the activities were not exploited, most significantly there was not enough time to complete the details of the map, discuss the implications of what was plotted, and connect the above and below ground models. Follow-up activities with Class 3 students to complete this would maximise the educational benefits and increase in awareness. This could include the running of a social survey to gather more data for the mapping.

Further activities could be conducted to mainstream children as leaders or key actors in water management. This could be beneficial to the education of children and their development as active and engaged citizens, to the community, and other stakeholders. These activities could include the running of a social survey to gather data for water and climate monitoring, involving children in monitoring, involving students in risk assessments.

Attempts to engage the wider community using P3DM produced mixed results. Attendance at the community day was high, with approximately 50 parents and community leaders attending. However, this was both a one-off activity and limited in scope to those with children in Class 3. With adequate ground work, planning and involvement of entertainers during the community consultation, attempts could be made to involve more community members.

There are a multitude of benefits in pursuing wider engagement through P3DM to the BIVA project. P3DM could serve as a platform to discuss water and inundation-related issues with the community, and thus presents an opportunity to incorporate local knowledge regarding geomorphic changes from wave action and inundation events into the BIVA project. P3DM could also extend the educational benefits and increased awareness demonstrated by the students to the wider community, and foster participation in water resource management by the community.

[4] Time constraints were due to the recognition that project activities should not reduce the necessary time for other core school educational programmes. An alternative option may have been to run the activities as a separate after-school or holiday programme.

The map could also be used to communicate the location, purpose of infiltration galleries, boreholes, and equipment used within and beyond the BIVA, which may serve to reduce suspicion and distrust by the community and, therefore, reduce the likelihood of vandalism. Interestingly, when asked to map the water reserve boundary, students believed it to be around the water treatment plant only. This may reflect a lack of understanding of the concept of the water reserve in the children, but may also reflect a broader lack of understanding in the entire Bonriki community. Given the contentious nature of land-use activities and encroachment of illegal settlement on the water reserve it may reflect a lack of understanding in the community regarding the reason for this restriction.

P3DM has potential beyond the scope of BIVA due to its strength in providing a platform for dialogue with stakeholders from diverse backgrounds, forms of knowledge, interests. It could be used to coordinate projects being undertaken by different stakeholders to ensure that communities and other stakeholders who are potentially not communicating, are aware of the scope and purpose of different projects. P3DM can also be used for initiatives attempting to delve into the underlying social, cultural, political and environmental complexities that cause and comprise water-related issues faced by Kiribati, as well as other related or unrelated development challenges such as health, sanitation and sustainable livelihoods

8. References

Banaynal R. and Dwamena E. 2011. Enhancing food security, climate change and sustainable development planning in Ghana using participatory three-dimensional model map. Journal of Sustainable Development in Africa 13(4):155–165.

BoM (Bureau of Meteorology). 2014. Tidal Predictions for Kiribati – Betio January 2014. Commonwealth of Australia 2014, Bureau of Meteorology. [Online] Available from: http://www.bom.gov.au/ntc/IDO60012/IDO60012.201401.pdf

Cadag J.R.D. and Gaillard J.C. 2012. Integrating knowledge and actions in disaster risk reduction: The contribution of participatory mapping. *Area* 44(1):100–109.

Gaillard J.C. and Cadag J.R.C. 2013. *Participatory 3-dimensional mapping for disaster risk reduction: A field manual for practitioners*. Catholic Agency for Overseas Development, London.

GWP. 2011a. The Sustainable Water Management Training Manual for Water Management Committees – Republic of Kiribati. For the Government of Kiribati, July 2012. Oxfordshire, UK: GWP Consultants

GWP. 2011b. Buota Consultations: 16-17 and 20 December 2010 Interview Results, for Government of Kiribati, Kiribati Adaptation Project Phase II – Kiribati Improving the Sustainability and Supply of Freshwater, KAPII: FSS0943 FS-07/2009 Oxfordshire, UK: GWP Consultants

KNSO and SPC 2012. Kiribati 2010 census. Volume 2, Analytical report. Kiribati National Statistics Office and the Secretariat of the Pacific Community Statistics for Development Program

Rambaldi G. and and Callosa-Tarr J. 2002. Participatory 3-dimensional modelling: Guiding principles and applications. ASEAN Regional Centre for Biodiversity Conservation, Los Baños, Philippines.

9. Appendices

Appendix A: Summary of Previous Community Engagement Activities

Appendix A1: Public Utilities Board (PUB)

Appendix A2: South Tarawa Sanitation Improvement Sector Project (STSISP)

Appendix A3: Aviation Authority

Appendix A4: Kiribati Adaptation Project Phase II (KAPII)

Appendix A5: Kiribati Adaptation Project Phase III (KAPIII)

Appendix A1: Public Utilities Board (PUB)

The PUB has a history of undertaking community engagement programs related to the Bonriki and Buota water reserves and water supply infrastructure with mixed success. Most recently they have done presentations at primary schools across South Tarawa with the aim of increasing public awareness on their responsibilities and obligations for the use of water supply and power assets.

Table provides a summary of the activities undertaken by PUB and highlights the successes and challenges involved with past programs. Items of particular relevance to the planning of community engagement activities for the BIVA project are:

- The PUB has recently established a village committee to assist with communication of PUB information and messages throughout the village. There may be opportunity for the BIVA project to use this committee as a forum for disseminating information and arranging community meetings.
- The mwaneaba meetings and school awareness activities were most successful where educational entertainment was provided as this increased attendance, however there was limited engagement during road shows as illustrated by a lack of questions asked or responses from participants.
- The PUB is interested in collaborating with the MPWU Water Engineering Unit (WEU) on future engagement activities and the planned BIVA project activities could facilitate this partnership.

Table A1. Summary of Public Utilities Board community engagement activities.

Questions	PUB Comments
Current and planned engagement activities	1. Plan to establish a working group/committee in all villages on South Tarawa including Bonriki – they have already identified members for a working group in Bonriki – plan to conduct a one-day workshop but are still looking for funding. The Working Group will be the communication arm of PUB. The group will make information gathering and dissemination easy. For instance, when they work with Bonriki, their working group will assist by inviting members to the meeting and these members will then disseminate the messages and outcomes of the meeting to the entire village. 2. The mwaneaba consultations in Bonriki and school visit have already been completed.
Engagement activity aims	– Disseminate message on responsible I-Kiribati or citizenship responsibility. – Educate public to look after PUB assets. After all, PUB equipment are all theirs, therefore they should look after them. – Sustainability.
Key messages	General – covering all PUB services to the public (i.e. water supply and power).
Engagement activities target audience	All levels, including older people in the mwaneaba, youth groups from different churches and primary school children.

Questions	PUB Comments
Past activities	Previously, just mwaneaba consultations and senior secondary school student visits were made. The following are list of activities: 1. mwaneaba consultation 2. Road show 3. 50 programme 4. School visit 5. Develop radio spot (up to 1 min) In 2013, they had visited all primary schools in South Tarawa including Buota except for Temwaiku. They disseminate the same message but the language is different. In other words the language level used depends on their target audience.
Effective past programmes	– Mwaneaba visits, road shows and school visits were all successful by inviting other parties to form part of the team mostly entertainers such as band/Karaoke, youth group entertainers. – With radio they first used 50 programmes for three months, followed by fortnightly business hour radio programme for another three months and then a series of monthly radio spots for more than three months now.
Challenges with past programmes/ activities	– Poor attendance and participation. – Mwaneaba (usually church) visits sometimes restrict other church members to attend PUB programmes because they belong to other denominations although they lived very close to the mwaneaba. – Road shows usually receive very little or even no participation from the public in terms of questions and responses. – Cost: transport, PA system and entertainers.
PUB recommendation	– Appreciate to work in collaboration with Water Engineering Unit. In this way, they can assist each other for instance with knowledge and skills they have to approach various community. Two heads are better than one. If we could team up with them then we might be able to answer and or to respond to various questions that will be raise by community from two different angles

Appendix A2: The South Tarawa Sanitation Improvement Sector Project

The South Tarawa Sanitation Improvement Sector Project (STSISP) is implemented by the Ministry of Public Works and Utilities within the Water Engineering Unit. This project focuses on the whole of South Tarawa. The community engagement component of the project involves 10 community mobilisers. The mobilisers disseminate messages on proper disposal and proper use of toilets (improvement of the sanitation and hygiene practices of South Tarawa's residents).

Table provides a summary of the activities undertaken by STSISP and highlights the successes and challenges involved with current programmes. Items of particular relevance to the planning of community engagement activities for the Bonriki Inundation Vulnerability Assessment project are:

- STSISP introduced and built capacity and awareness on how the community should manage their own resource. This might be helpful to protect vandalism issues for government property and also enable community willingness to stop asking for allowances and mwaneaba fees.
- Mwaneaba consultations were considered an effective awareness tool and are a good cultural/social practice. These meetings allowed for a question-and-answer period by members, although often there were problems with poor attendance.
- The road show used an interactive theatre where questions were asked of the public. However, this was not effective because there was limited interaction and feedback from community attendees.
- The puppet show was successful and attracted larges audiences. The community was most inspired by this because it was a new form of media.

Table A2. Notes from meeting with STSISP community mobilisers.

Questions	STSISP views
1. What engagement activities are currently happening/ planned?	Community mobilisers had been doing lots of awareness programmes on South Tarawa. Each mobiliser had been assigned to different communities on South Tarawa depending on where they lived. For instance, a mobiliser who lives in Bikenibeu was assigned to do an awareness in Nawerewere, Temwaiku, Bonriki, Tanaea and Buota.
2. a. Aims	Disseminate message on proper disposal and proper use of toilet (improvement of the sanitation and hygiene practices of South Tarawa's residents)
b. Message	Messages that have been delivered: – Proper disposal of nappies and women's pads – Proper usage of toilet – Impact on open defecation – Good practices on hand washing with soap
c. Target audience	All level such as older people in the mwaneaba, youth groups from different churches, primary school kids by visiting the schools.
3. What has been done in the	The following are list of activities that had been carried out in

past?	Bonriki: 1. Mwaneaba consultation 2. Road Show — work with one community, campaign on proper disposal 3. Workshop/training — Kawai ae e boou 4. School visit — Story teller and games 5. Develop radio spot (up to 1 min)
4. Effective programmes in the past	– Mwaneaba consultation- it effective as it's a formal meeting that is arranged formally by the community chairperson. Members have time to ask questions. – Road show — applied an interaction theatre, where audiences have time to answer questions that had been developed by mobilizers. – Puppet Road Show an inspiring tool to deliver the message on hand-washing and hygienic practices as the general community really inspired as puppets are really new to their communities. – With radio they first used 50 programmes for three months, followed up by fortnightly business hour radio programme for another three months and then a series of monthly radio spots for more than three months now.
5. Challenges with past programmes/activities	– Poor attendance with low numbers and participation. – Mwaneaba (usually church) visits sometimes restrict other church members to attend because they belong to other denominations although they lived very close to the mwaneaba. – Cost: transport, PA system and entertainers.

Appendix A3: Aviation Authority

The Aviation Unit operates in Bonriki and, like the water reserve, has experienced issues with conflicting land-use activities. The Aviation Unit has recently been working closely with the Bonriki community as there is a planned upgrade to the Bonriki airport. This is a big project and has a number of activities that they need community assistance with while this project is implemented. Although this project is not water related, its location in Bonriki and close interaction with the Bonriki community is relevant.

A3 provides a summary of the community engagement activities undertaken by the Aviation Authority and highlights the successes and challenges involved with their programmes. Items of particular relevance to the planning of community engagement activities for the Bonriki Inundation Vulnerability Assessment project are the following observations:

- To avoid poor attendance, target community gathering events such as church services.
- Seek assistance from the Whole of Bonriki chairperson and get his involvement with every mwaneaba visit. This approach does not require much energy because the chairperson can organise the meeting by contacting each leader from different communities.
- It is important to let the community know that the project is theirs and it has been implemented for their benefit.
- 50 Program is a BPA (Broadcasting Publication Authority) programme that is live for 50 minutes each week. The cost is AU$350. The sponsor will provide questions for the public to answer and that question should relate to the message that needs to be disseminated to the public or for awareness. BPA provides phone numbers to the public to call, if that person's answer is correct, then they have the opportunity to say something to their friends or family with no charge. This is broadcast through the whole of Kiribati.

Table A3. Notes from meeting with Aviation Authority manager.

Questions	Aviation Authority manager comments
1. What are the ongoing engagement activities?	– For every community engagement, first approach Whole of Bonriki chairperson asking for his or her assistance to arrange meetings. This is an easy and cheap approach. – It is essential to involve the Bonriki chairperson in every mwaneaba visit because he or she can control things that happen during the consultation. – The Aviation Authority team has established a subcommittee in Bonriki that includes the Whole of Bonriki chairperson, Bonriki councillor (Mr Timote) and Unimane rep. There is no allowances given to them taking into account that they will feel a sense of ownership to the Project.
Key message	Updates on the activities related to Bonriki Airport upgrading.
List of programmes	1. Mwaneaba consultation that is organised by Bonriki chairperson 2. School visit — making announcement during assembly time 3. Church — develop church announcement 4. 50 Program with BPA — it is worthwhile but expensive
Effective	– Mwaneaba consultation because it is an easy and cheap approach. – Working with Bonriki subcommittee as their working group, if there is a need.

Questions	Aviation Authority manager comments
programmes	– Develop announcement to be given during service both in Romon Catholic and Kiribati Protestant Church.
Challenges	Community might ask questions that are not relevant.

Appendix A4: Kiribati Adaptation Project Phase II (KAPII)

Water Management Training Manual

Under the KAPII project, the Sustainable Water Management Training Manual for Water Management Committees (GWP 2011a) was developed. This manual includes guidance on running educational activities to develop awareness and knowledge of a range of topics related to water resource management. The following can be used and adapted for the BIVA project:

- the water cycle
- water and climate change
- freshwater pollution and protection.

The resources provided within the manual include:

- Water Lens Protection Bingo, and game board for water lens protection Bingo
- Well Water Pollution Survey Chart
- Theory material on Water Lens Pollution and Protection in I-Kiribati.

The activities were trialled at IHC school in Taborio. These resources could be used with the Bonriki schools.

Buota Consultations

KAPII project undertook community consultations in Buota in 2010 related to the transportation of water to South Tarawa and to:

- understand the reasons behind vandalism done to the infiltration galleries; and
- provide a forum for community views on how the infiltration galleries could be protected from damage in the future.

Lessons learned and presented in the report Buota Consultations: 16–17 and 20 December 2010 Interview Results (GWP 2011b), that are relevant to the planning of community engagement activities for the BIVA project are:

- More recent vandalism to water supply infrastructure is mainly due to the value or usefulness of materials stolen, the restlessness and high rate of unemployment, irrational behaviour due to drunkenness, and unaware children.
- Activities occurring on the reserve that impact the groundwater quality include pit toilets and open wells, open defecation, livestock and dogs, graves and littering, and limited understanding from residents as to what activities were allowed on the water reserve.
- It is important that there is transparency and community involvement with government decisions and actions related to the reserve, and including the local unimane (village leaders) is important.

Appendix A5: Kiribati Adaptation Project Phase III (KAPIII)

Coastal Engineering Works

The KAPIII programme includes design of coastal protection works. In November, the KAPIII Coastal Engineer, Cliff Juillerat, attended the Bonriki Inundation Vulnerability Assessment (BIVA) project site during installation of oceanographic equipment on the reef flat and indicated the possibility of collaboration between the two projects.

For the KAPIII design of coastal protection works, simplistic two-dimensional empirical wave transformation equations are being used to obtain design conditions at the back of the reef. BIVA field data could be used by the KAPIII programme to compare results with these empirical methods and improve design assumptions.

Unfortunately, because the KAPIII programme is already at detailed design phase, the timing of the two projects may not allow for the use of the BIVA data. However, there may be an opportunity for the BIVA project to utilise some of the KAPIII findings and design outputs. Communication with the KAPIII team should be maintained to ensure that there is not duplication of effort and that sharing of knowledge and information occurs.

Appendix B: Notes on the participatory mapping scoping mission

BIVA project
Notes on the participatory mapping component in following the scoping mission to Tarawa – 28 July-4 Aug. 2013

JC Gaillard
School of Environment, The University of Auckland

Issues

- The first and foremost issue is that we haven't been able to talk to the first concerned in the context of a participatory project, i.e. the members of the local community(ies). So what we know about the locals is based on second-hand accounts and these may somehow be biased in different directions for many reasons which we do not know.
- Along the same line, we haven't been able to identify strong community(ies) representative partner(s) although some have been suggested or approached, e.g. churches, the elementary school, women groups.
- There seems to be at least two if not three different communities living within or in the immediate vicinity of the water reserve, i.e. the long-term settlers who inhabit the southern fringe of the reserve along the airport runway, the migrants who have settled along the ocean shore on the northern border of the reserve, and maybe a third distinct community (but some seem to be related to the ocean side villagers while others allegedly are related to the original settlers from the southern village). Since both those living on the ocean shore and those settled within the reserve are occupying land owned by families of the southern village it seems that some form of patronage or unbalanced relationships tie the different communities.
- The water reserve has been established on a land which had long been used, at least, for farming and burying the dead. In that sense, the government policy conflicts with traditional land use.
- The recent recommendation made by the General Attorney to evict those households living within the perimeters of the water reserve further complicates the situation by allegedly (we haven't talked to those concerned) accentuating the tense relations between the government and the locals.
- SMEC is already running a community-based project in Bonriki but is struggling to build rapport with the community(ies) and does not recommend that we carry out a parallel project involving similar community partners.
- The relationships between the different potential government stakeholders of the P3DM activities (see below) are unsmooth.

Possible local stakeholders

- Local community(ies) through unidentified partner(s) (churches? women groups?): identifying those partners will require time and trust – see below. We can't continue with the P3DM activities if these stakeholders are not the strongest of all.
- SMEC: we may ride on their back and use their ground work to avoid further project fatigue and conflict with SMEC government agency partners (see below). Maybe not the option thought given the possible differences in the way we conceive participatory work.
- airport administration: this seems to be a potentially very valuable partner because of its experience in dealing with the local communities and location on top of the water lens but how to hook them onto the project, i.e. how do we make the connection between the airport and the water?

- elementary school + high school: the elementary school may be a very interesting partner in the sense that schools are often rather neutral in conflicts such as those observed in Bonriki. In addition, it would be easy to hook the project onto the regular class activities through social sciences and science classes, including running social survey to gather preliminary data or empowering the kids with some water and climate monitoring tasks. However, the capacity of the local elementary may be limited.
- MPWU: can we rely on the alleged dedication of the water unit to the success of the P3DM activities, including to storing the map, organising regular activities beyond the time frame of the project, etc.? Hopefully yes and in that case this is likely to be the key stakeholder.
- PUB: it could be a very good and reliable partner in collaboration with MPWU as it currently relies on spatial data and GIS maps. We haven't talked to their PR officer though. This person may be the most interested although we do not want that the map become a display tool for PR purpose only.
- MELAD, MFMRD, MHMS, ME: Too many stakeholders around the table in such a complex setting may be a problem as it would require extra facilitation care and preliminary trust and mutual understanding of what we all want to achieve.
- KAP III: an important stakeholder on paper but in reality their role may be limited as it might potentially overlap with that of GSD.
- NGOs we haven't been able to talk to them and none has replied to our most recent emails so far.
- UNICEF: an institution which seems interested and which may understand issues associated with the tool and participation but which may have other concerns on the short-term.

Opportunities for initiating P3DM activities

- The airport administration seems to have been relatively successful in running community group discussions around the future development of the runway, which means that engaging with the community is possible.
- The apparent multiple land-related and stakeholder conflicts around and within the water reserve is a strong rationale for developing P3DM activities as the tool has proved successful in overcoming such difficulties and fostering dialogue in other contexts.
- The very structure of the project and the key role of the GIS database to integrate data from different scientific parties provide a real opportunity for going ahead with the P3DM activities as it would be easy to further include community data and perspective in the database. These data could include land use; lifelines and infrastructure; housing; household demographics and health; household resources such as farming, fishing, businesses, quarrying, wells, vehicles, animals, incomes, remittances, etc.; water usage; hazard mapping. At the same time, P3DM would offer the opportunity to scientists to discuss water- and inundation-related issues on a tangible and commonly-trusted tool with the locals.
- The synergy created during the scoping mission with hydrogeologists and discussions around new developments for the tool, i.e. the underground modelling of the water lens and related facilities, constitute an exciting opportunity for pushing through with P3DM.

Challenges in developing P3DM activities

- We are not grounded enough in the local community(ies) and building trust will take a long time.
- Building rapport with the community means dealing with SMEC which is already trying to do so through an approach which is different from what we envision. Their community organisers do not live in the community and just come for specific activities. If we overlook SMEC we might be able to

build trust with the community but this may be at the detriment of our relationship with government agencies involved in the SMEC project.

- If we are to move on with the P3DM project we need to engage with those 'illegal settlers' living within the perimeter of the water reserve. If we do so we would somehow give them some form of legitimacy, especially because we officially work with government agencies, which may be problematic.
- P3DM emphasises land use and land-related issues, including conflicts. If it theoretically has the potential to solve conflict it may work otherwise if not properly facilitated. We do not want to further fuel existing conflicts, not only between the government and the 'illegal settlers', but also between settlers themselves. This seems to be a critical issue in Tarawa. Ditto for mapping locations associated with illegal activities such as sand quarrying. Once data are plotted on the map they are made tangible to everyone. In addition, they are not anonymous anymore when associated with a particular household.
- Facilitation is therefore a crucial issue. We need to find a highly-skilled and locally trusted and grounded facilitator to run the activities along those mastering the P3DM tools.
- Because of the lack of strong and dedicated partner the sustainability of the tool would be unsure at this stage. Yet, P3DM is not a tool which is meant to rely upon a one-shot activity. It is most useful when used for action planning and monitoring on the long-term, which warrant regular updating and care. If we go ahead with the P3DM activities, there is a possibility that the map be used for display only and, in the worst case scenario, be abandoned once the facilitators step out.
- Ultimately there is an issue of accountability. As soon as we engage with the local community(ies) we are accountable to them as per the principles of participatory work. There is a danger indeed that to meet Ausaid expectations we push for whatever we want at the detriment of the locals' will, needs and expectations, which would be ethically problematic.

Overall assessment and way forward

There are obviously more challenges than opportunities for implementing P3DM in Bonriki in the context of the BIVA project. The key issue is whether we can properly engage with the local community(ies) and build trust because we could virtually work with the sole locals and then see what to do with other stakeholders a posteriori. If we come in without the government agencies on our back this may somehow put us in a more comfortable position vis-à-vis the eviction notice. This is not the ideal scenario given the potential of the tool for fostering dialogue amongst stakeholders but this would meet the objectives of the project (2.2 and 6.1) and this would ethically be fine.

The foregoing 'community-only-in-a-first-time' approach however requires to spend time living with the locals and sharing the daily life, which further warrants an entry point, i.e. a local partner. This is very different from the SMEC approach. In that sense, it is essential to send someone skilled with both community work and P3DM to lay the ground and prepare for the activities, including understanding local issues, defining common objectives with the locals, anticipating the sustainability of the tool, defining the scale of the map and the storage area, identifying the participants, preparing the materials and other requirements (food, drinks, etc.). Again to do that we need an entry point.

From now on, the key determinant for whether we go ahead or not is therefore our ability to identify this entry point, be it the elementary school, a church or a community-based group (e.g. women group). If we are not able to do so in the coming months, then it may be not be worth continuing as the number of issues to overcome may be too much.

Appendix C: Materials from mwaneaba consultations November 2013

Appendix C1: Poster (English version)

Appendix C2: Notes from mwaneaba consultation in Bonriki

Appendix C1: Poster (English version)

Bonriki Inundation Vulnerability Assessment (BIVA) Project

THE BIVA PROJECT: QUESTIONS AND ANSWERS FOR COMMUNITY MEMBERS

This leaflet is designed to help inform communities and residents on Bonriki about the activities, goals, and purpose behind the Bonriki Inundation Vulnerability Assessment Project (or BIVA). Starting in 2013, BIVA is a two-year research project funded by the Australian Government and conducted by technical experts from the Applied Geoscience and Technology (SOPAC) Division of the Secretariat of the Pacific Community (SPC) in partnership with the Kiribati Ministry of Public Works and Utilities.

BIVA project area covers 4 km² of the Bonriki Groundwater Reserve and surroundings on Tarawa atoll, Kiribati. It includes the international airport facility to the south, the fringing reef flat to the east, the intertidal sand flats to the south, and the channel and islet to the west.

WHAT WILL THE BIVA PROJECT DO?

The BIVA project will measure wave activity on Bonriki's reefs and coastlines. The measurements collected will help us understand how likely it is for waves to flood coastal areas and for salt water to threaten the Bonriki Groundwater Reserve.

WHY IS IT IMPORTANT?

The Bonriki Groundwater Reserve is the Public Utilities Board (PUB)'s main source of freshwater, and more than half of South Tarawa's households depend on the PUB water supply as their primary water source. The project will improve our understanding of the freshwater available and help us protect it. It will also give the Government of Kiribati the information they need to to enhance the design of public water supply.

HOW WILL BIVA MEASURE THE WAVES?

We will be installing two different kinds of instruments along the Bonriki reef which will collect information about wave height, water flow, and temperature.

ARE THE INSTRUMENTS DANGEROUS?

The measurement instruments are not dangerous to humans and do not affect the environment. They do not damage or harm the water, the marine life or the reef. They will only collect data from the waves and will be removed after one month when the data collection is complete. It is important not to touch or remove these instruments.

HOW WILL THIS PROJECT IMPACT MY EVERY DAY LIFE?

This project and the instruments being used should not interfere with your daily activities at all. You may see some of the project staff installing the instruments, or conducting surveys in the area around Bonriki Groundwater Reserve. Feel free to ask them about their work! After they collect the data they need, most of the rest of the project will be done on computers. We look forward to sharing our findings and the final results with you and your community when the BIVA Project is completed toward the end of 2014.

WE NEED YOUR HELP!

You can help insure the success of this project to better understand and protect Tarawa's freshwater. Please

- Do not tamper with the instruments – they have no commercial value in Kiribati, but are collecting important data
- Instruct children to stay away from the instruments
- Inform other members of the community on what the instruments are in the water for

PROJECT CONTACT?

If you have additional questions or concerns about the BIVA Project, or would like to report damage to one of the instruments:

SPC
Mr. Jens Kruger
Team Leader, Oceanography (SPC-SOPAC)
Office Tel: +679 338 1377
jensk@spc.int

Local Contact
Ms. Reenate Willie
Ministry of Works and Energy
Office Tel: +686 28192
reentearikii@gmail.com

Types of Instruments BIVA will use

The instruments will be in the water for 1 month, from November to December, 2013. The instruments are only used for scientific research and have no commercial value for any other purpose.

This Tide and Wave Recorder measures tides, temperature and waves.

This Acoustic Doppler Current Profiler measures current speed & direction, temperature and pressure.

Appendix C2: Notes from mwaneaba consultation in Bonriki

A. Brief summary of activities

Mwaneaba consultation had been carried out from Tuesday (5/11/13) to Thursday (7/08/11) and as well as on Monday (11/11/13). Below are the staff that assisted with this consultation:

1. Phoebe Mack
2. Aseri Baleilevuka
3. Zulfikar Begg
4. Maiango Enota.
5. Mark Buckley (UWA)

B. List of mwaneabas and questions raised

1. Bareaumai Primary School

Dates: Tuesday, 5/11/13
Total number of students: 355
Head mistress: Aititino
Officers attending: Aseri, Zulfikar, Phoebe and Maiango

No questions had been raised by students; therefore, the presenter (Maiango) provided a list of questions to school children.

2. Arobati 3

Total number of participants: men 15, women 2
Tia babaire (Chairman): Temetika
Officers attending: Aseri, Zulfikar, Phoebe and Maiango

Questions raised:
1. Seeking funding from this project regarding coastal erosion issue. Express that erosion is happening ,however, can this project assist.

2. Is there any fine if these machines are vandalised?

3. Is there any environmental impact from this machine?

4. What happens if someone touches the machine, is it harmful?

5. Is there going to be a watchman?

3. Ngeabwa mwaneaba

Total number of participant: men 5, women 6
Tia babaire (Chairman): Kauree
Officers attending: Aseri, Zulfikar, Phoebe and Maiango

Questions raised:
1. A concern was raised that if BIVA staff need assistance with machine instalment, it is better to engage Bonriki community members rather than people from outside Bonriki. Their involvement in this project will enable them to have a sense of ownership.

2. Clarification was sought on the total number of machines to be installed in the ocean and how it works.

3. The exact location of the machine was asked about, so that community members can assist in looking after it if it is close to their homes.

4. It was also mentioned that there are many fishermen divers in Bonriki, and they might have to touch the equipment; therefore, it is would be best to approach the Bonriki chairman to seek his assistance, because he has more power to control the Boniriki community.

5. Suggest the erection of a signboard to explain the project and the reasons for the instruments.

6. Ngeabwa's chairman express that he ready to assist to look after the equipment, but not knowing what others might think about the equipment, they would vandalise the equipment. In this regard, it better to seek the assistance from the Bonriki chairperson (tabuki) before it happens.

7. Comments were given on the pamphlets, which are very informative.

4. Arobati 2 mwaneaba

Dates: Thursday, 7/11/13
Time: 3.30 p.m.
Number of participants: men 1, women 11
Officers attending: Aseri, Zulfikar, Phoebe and Maiango and Mark Buckley (UWA)

1. When are the machines to be installed?
2. Request the exact time and dates for BIVA team to share their data with them.
3. What happens if the machine is vandalised or broken?

5. Tokarake mwaneaba

Dates: Thurs, 7/11/13
Time: 5.00 p.m.
Number of participants: men 11, women 1
Officers attending: Aseri, Zulfikar, Phoebe and Maiango

1. Clarify on the location of the machines.
2. How many watchman are needed?
3. Advise that Bonriki chair, together with his committee member, will assist on selection of watchman and Nabubura will coordinate watchman.
4. Asked for sign board, we noted that posters are being provided to each village mwaneaba

6. Arobati 1 mwaneaba

Dates: 7/11/13
Time: 6.00 p.m.
Number of participants: men 14, women 7
Officers attending: Aseri, Zulfikar, Phoebe and Maiango and Mark Buckley (UWA)

1. Clarify the aim of this project.
2. Why was Bonriki targeted for this project?
3. What is the use of this project? Is there any benefit gain by Bonriki villagers?
4. Clarify the location of these machines.
5. How many machines to be installed on the reef?
6. Is there any harm caused from these machines, including to fish?
7. When will the data be provided?

Note: During this meeting a community member who spoke in English (and appeared drunk) spoke at length about the need to clarify what the project will provide the community, and requested 'proof' that the project was going to be worthwhile.

7. Te Utu ae e tabu mwaneaba

Dates: Mon, 11/11/13
Time: 10.00-12.00 p.m.
Number of participants: >100 (est.)
Bonriki committee members: Tabuki (chairman), Kirata (treasurer), Nabubura (coordinator)
Officers attending: Phoebe and Maiango

Note: This meeting was called by the Bonriki chairman (Tabuki Tekaiua) because previous meetings held by the committee resulted in too many unanswered questions and they were unable to resolve who would be appointed as security for the oceanographic equipment. Tabuki noted that future awareness activities should start with a Whole of Bonriki meeting such as this, and then smaller community meetings can be held if required. It was noted that 499 households are members of the community group that provides these households with a say in community decisions such as that discussed for the BIVA project.

Item 1: Engage Bonriki members for watchmen roles

1. Need to engage more than one person in the watchman role.
2. Seek clarification about the watchman's role and location of the equipment.
3. Inquire about watchman rates and raise concern regarding other allowances to be considered.
4. Raise concern about what if the machines are vandalised or broken. Hence, request that watchmen should do the work at night as well. This is because vandalism might happen during the night time.
5. What rates should the watchman receive, given that some of his time will be at night, and possibly the weekend?
6. Request that the watchmen should engage for one day instead of just four hours.
7. Why does this project use government rates, and why is this not a permanent post? Request to raise the watchman rate to AU$3.50.

8. In terms of reporting any problems to the officers, how should the watchman report an incident if they have no phones?
9. Request for watchmen's torch, if he/she is doing their duty at night.
10. Are wet weather and equipment allowances considered in this project?
11. Can the machines detect future waves?
12. For this project to go well, it must always consider occupational safety and health.

Community members agreed
Item 2: Labourers at Bonriki boreholes

1. Engaging more villagers in the future is the aim of this project.
2. Why not approach MLHRD instead of approaching the community?

Community members happily accepted the proposed rate of $25/day and agreed to vote on which members would take on these roles.

Appendix D: Inundation maps presented to community

Appendix D1: March 2014 wave and tidal data recorded

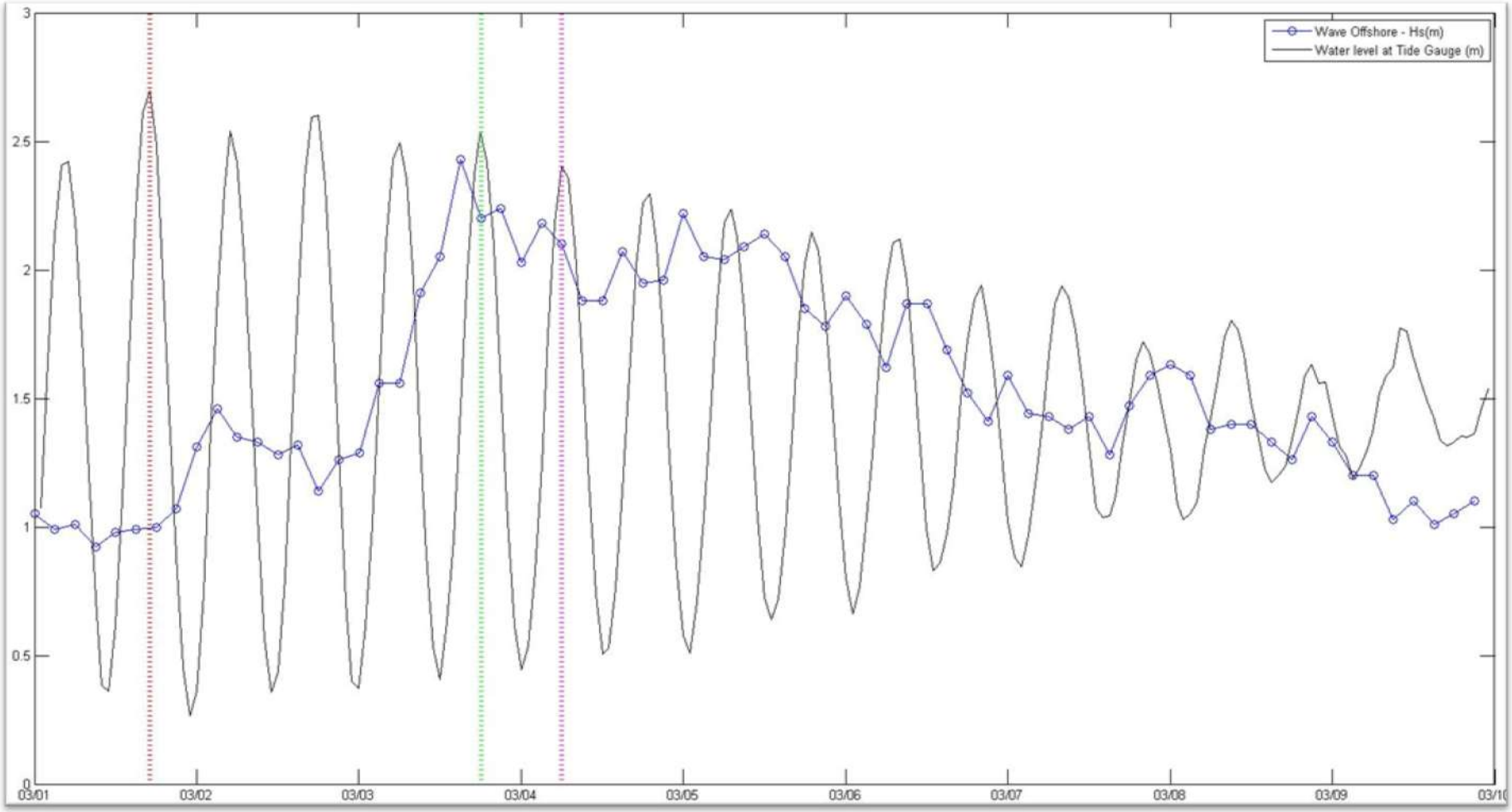
Appendix D2: March 2014 inundation map

Appendix D3: Moderate sea-level rise — Inundation map

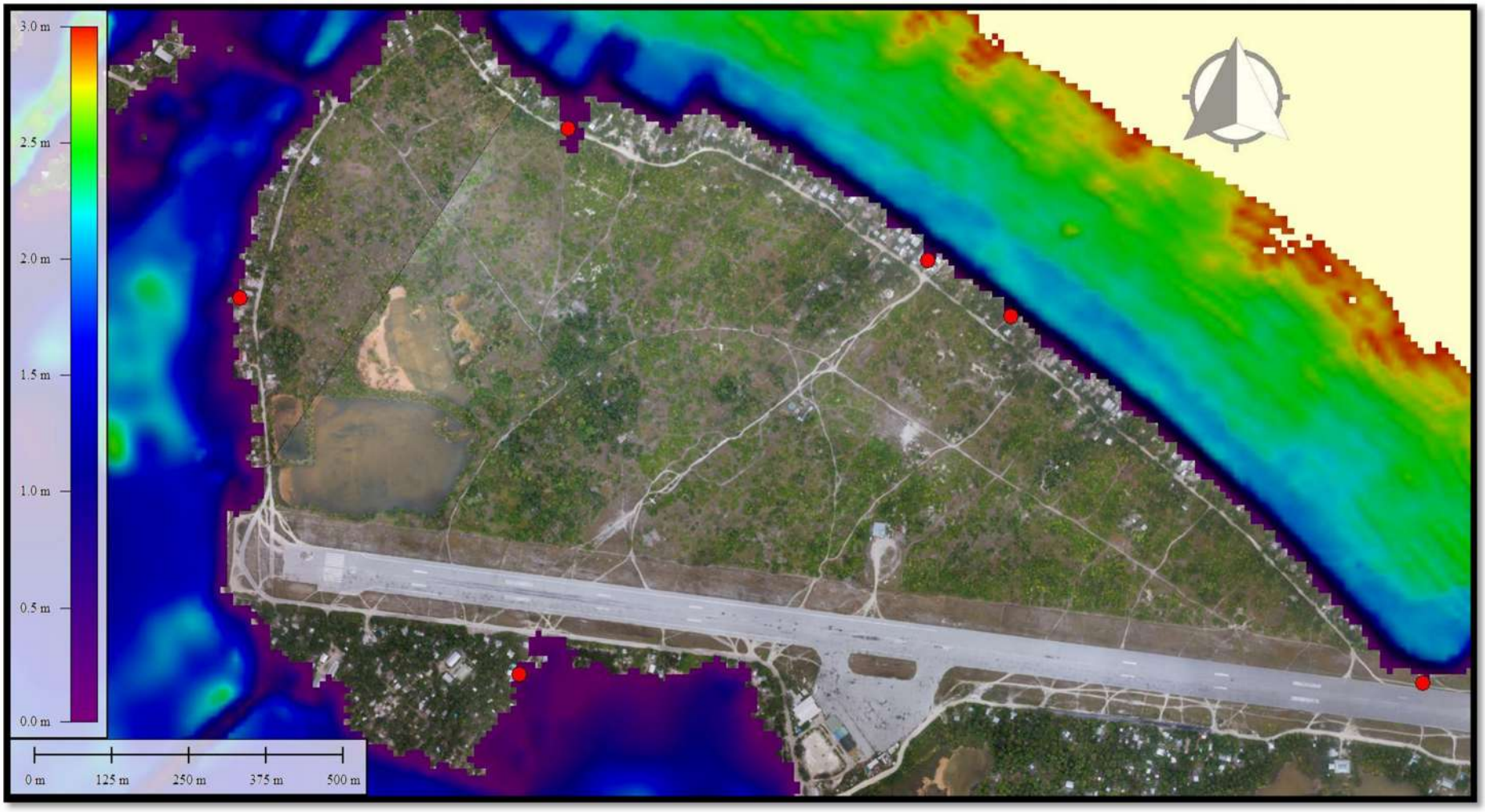
Appendix D4: Severe sea-level rise — Inundation map

Appendix D5: Extreme sea-level rise — Inundation map

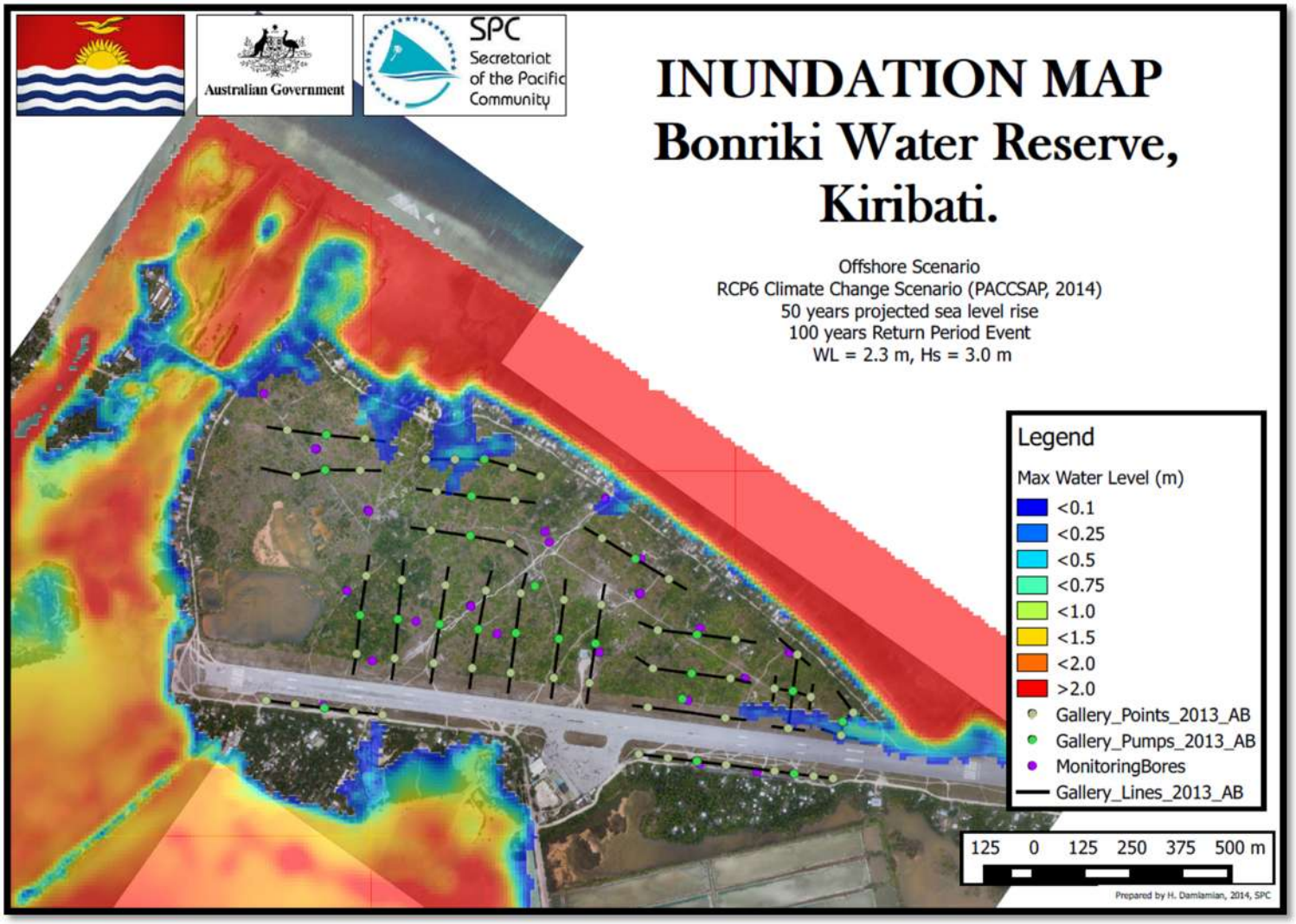
Appendix D1: *March 2014 wave and tidal data recorded*



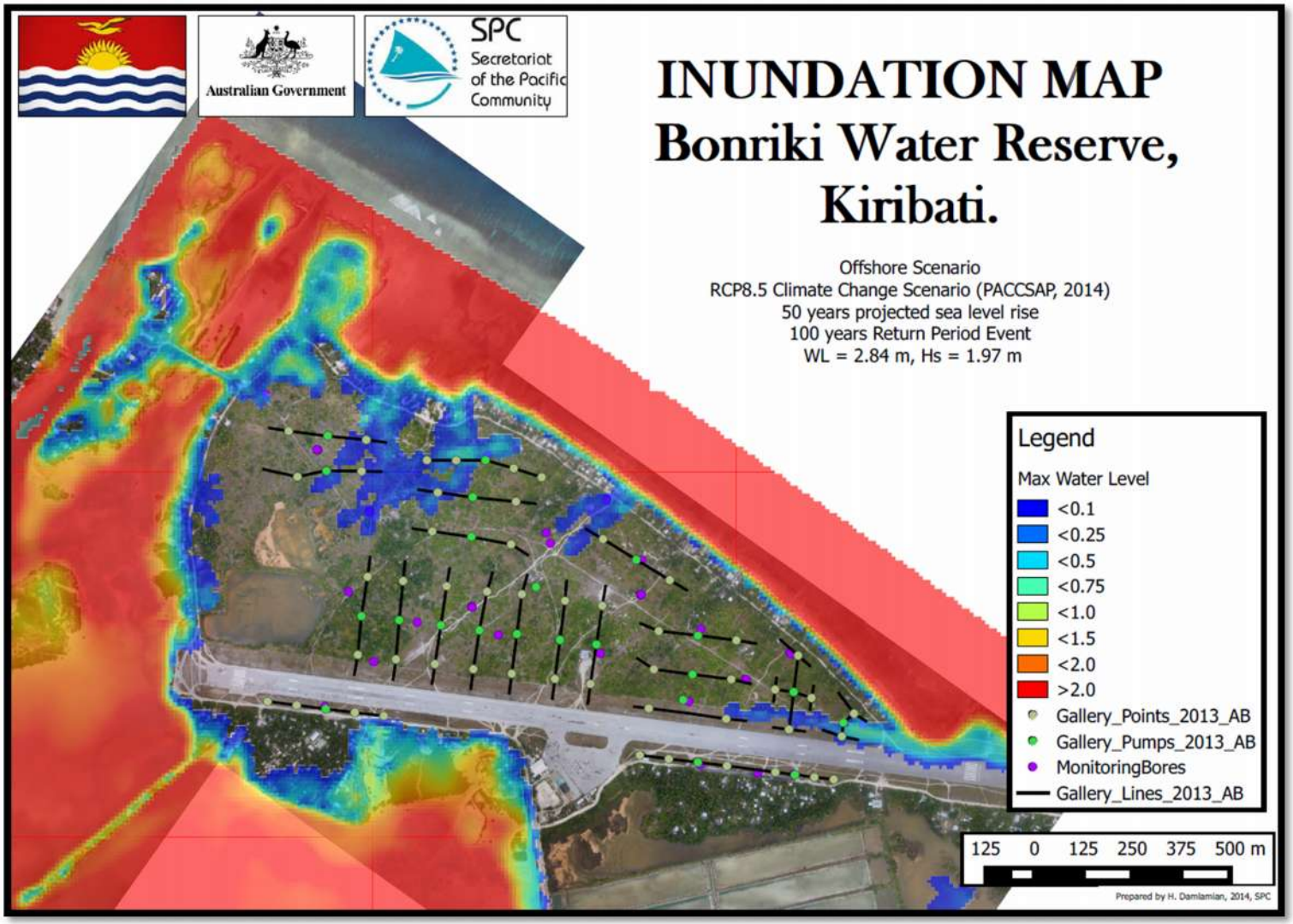
Appendix D2: *March 2014 inundation map*



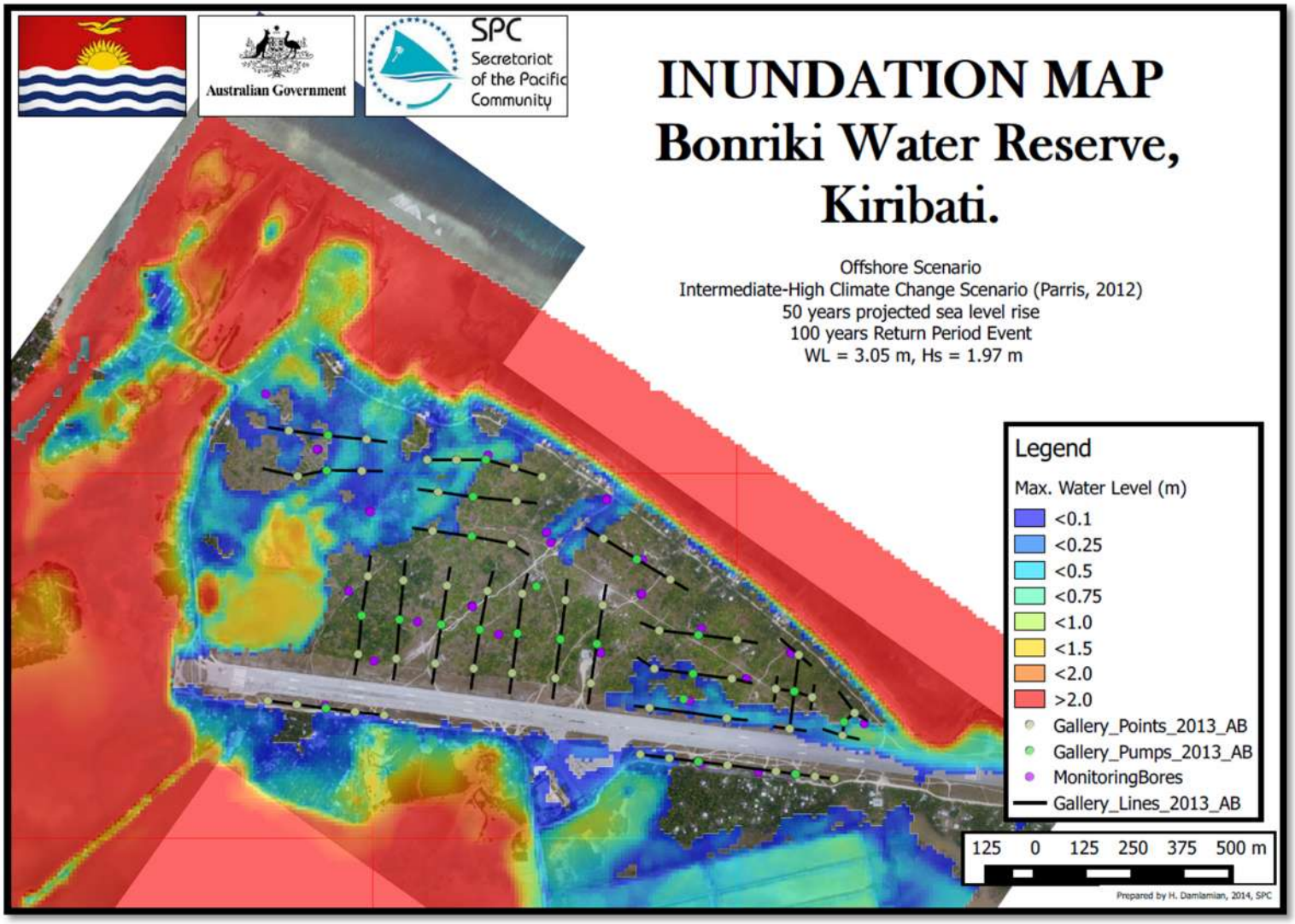
Appendix D3: *Moderate sea-level rise — Inundation map*



Appendix D4: *Severe sea-level rise — Inundation map*



Appendix D5: *Extreme sea-level rise — Inundation map*



Appendix E: Coastal Hazards Survey

Appendix E1: January 2014 king tide survey

Appendix E2: March 2014 king tide survey

Appendix E1: January 2014 king tide survey

Bonriki visit summary report

On Tuesday, 4 February at noon, Maiango Enota and one staff from the Water Engineering Unit (Erina) carried out a survey and interviewed Bonriki community members, especially those on the ocean side, starting from Miita residence. This home is opposite to the machine installed sites last year and the rest house for BIVA team during their installation period.

Results

Name of interviews	**Discussion**
Miita	-King tides are very dangerous to them as they live on the coastal site. Fortunately at this time, there was no wind, thus the influence of a king tide is not as dangerous as before. - She believed that this king tide is much higher than before. (refer to Fig. 1)
Miita's neighbour (eastward site)	- A pandanus tree had been surrounded by seawall, which completely destroyed during this high tide (refer to Fig. 2)
Abeton's house	Highly eroded. Approximately 1.5 m of sand was abover to be eroded above sea level (refer to Fig. 3)
Kibau's house	- exposed septic tank - believed that this high tide is much higher than before. - Members of this house have a video recording of Friday (31/01/14) and were happy to share it with us once we have an adaptor to copy it (refer to Fig. 5)
Keebwa's house	Their old cement floor had been destroyed by this high tide (refer to Fig. 6).

Photos

Figure 1: Miita's home.

a. Waves ran up to where the two people in the photo are standing.

b. Eroded coastal site in front of Miita's house.

Figure 2. Sand was eroded away from the base of this tree due to king tides.

Figure 3. There was a small seawall that surrounded a pandanus tree, which helped as protection from erosion. After the king tides, this seawall was completely destroyed, with only pieces of rocks left behind.

Figure 4: At the ocean side of Abeton's house.

Figure 5: looking eastward next to Abeton's house.

Figure 6: Kibau's residence.

The waves ran up to where the two ladies in the photo are standing, toward the house behind them.

Old cement foundation, broken after the king tides.

Figure 7: The second house at west side of Miita's house. The lady wearing the blue top mentioned that the waves ran up to where she sat. She feels terrible and said that she is worried that one day their home will be destroyed.

Figure 8: The tide ran up under the buia.

Figure 9: Tabokai's wife's residence. Members of this family mentioned that their place had not been eroded. The constructed seawall right next to their homes enabled them to gain more land at the coastal area.

Figure 10: Side view of KAP II seawall. A number of trees had fallen over due to the king tides.

Figure 11: Eroded end and interior of the KAP seawall.

Appendix E2: March 2014 king tide survey

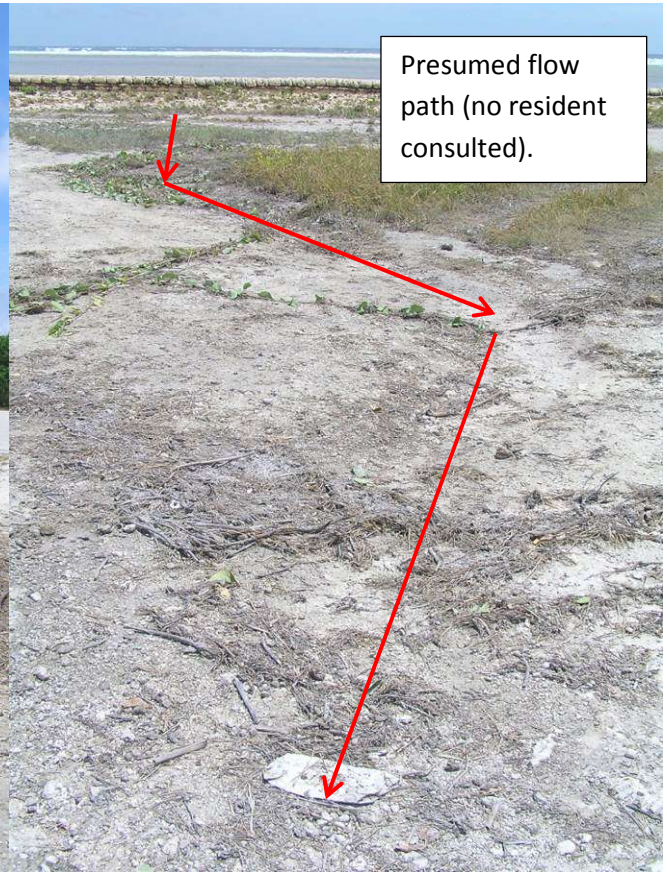
Household name	Village name	Lagoon/ Ocean	GPS coordinates	Max. distance the water came onto the land (m)	Run-up (height above normal level) (m)	Inundation event description
Taruru (IN4)	Bareaumai Primary School	Lagoon	N01 22 52.3 , E173 08 27.5	24	0.5	Water came up to below the knees on Monday 3/4/14 afternoon. No waves, just slowly rising. The land owner built a small wall to stop the water flowing into their property. It also happened in Jan but only ankle deep. Also mentioned that it also happened in previous years but this is the highest one they have ever experienced. Also, the water came up to the floor level of the pink house opposite Taruru's house, but the water was not above the floor.

Water came up from the lagoon and across road. Depth was above the bund.


Bund built to stop water coming onto land
Came approx. 50 cm high.


Water came to floor height, but did not go above floor/bricks.

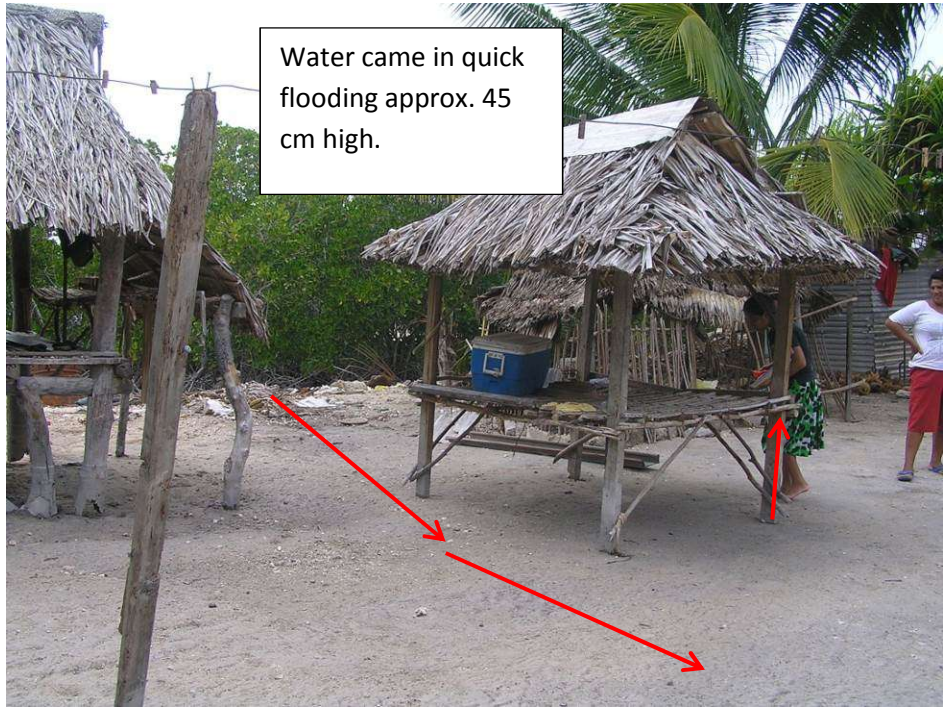
Household name	Village name	Lagoon/ Ocean	GPS coordinates	Max. distance the water came onto the land	Inundation event description
IN1	KAP II Seawall	Ocean	N01 22 52.9, E173 09 14.6	31.8	Distance based on debris washed up onto land. Estimates only as no water present and no local resident on site to verify. Appears that water almost reached the runway. From the grass, which is flattened, it is clear that there was water washing over the seawall onto the land.



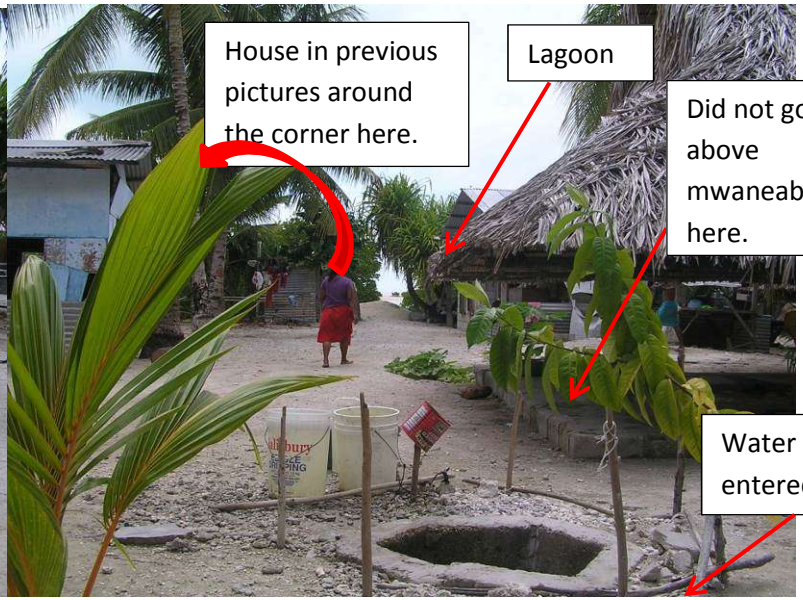
Household name	Village name	Lagoon/ Ocean	GPS coordinates	Max. distance the water came onto the land (m)	Inundation event description
IN 2	Far end of Bonriki Airstrip to Temaiku	Ocean	N01 22 54.3, E173 09 31.6	30.8	Miners on site explained that on Monday afternoon (3/4/14) the water went across the road, but not past the road. Large pools of water were still present on the road.

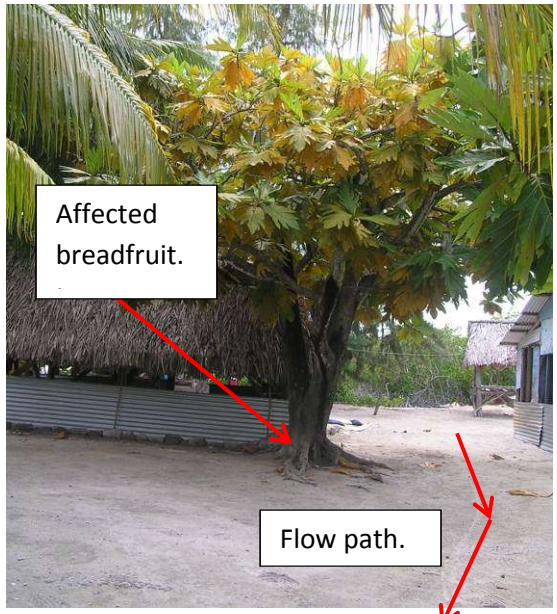
Household name	Village name	Lagoon/ Ocean	GPS coordinates	Max. distance the water came onto the land	Inundation event description
Maata and Tirikai (IN 3)	End of airstrip to Temaiku	Ocean	N01 22 55.6, E173 09 28.8	Up to the other side of the road	The water came across the road during high tide on Saturday (1/04/14) and on Monday (3/03/14). Did not pass the road onto the land on the other side.

Household name	Village name	Lagoon/ Ocean	GPS coordinates	Max. distance the water came onto the land	Run-up (height above normal level)	Inundation event description
IN 5	Anraei	Lagoon	N01 23 11.4, E173 08 13.2 (point taken next to the well)	28 steps	Approx. 0.45 m in depth on Monday	The water went up just a short distance from the road. The king tides happened in January but the water did not go as far onto the land. On site, the lady explained that on Monday (3/4/14) there was a quick surge that they thought it was a tsunami, the water level was just below the mwaneaba floor. She expressed that on Saturday (1/04/14) and Sunday (2/03/14) most houses were also flooded but the water only went close to the house, not passed the house towards the road and breadfruit tree next to the road. From the flooding on Saturday and Sunday they showed a breadfruit tree that had been affected by the saltwater (leaves are all yellow and brown). The Tanaea causeway on the other hand was flooded during the king tides period and the residents thought the sudden surge of water may be caused by the causeway overtopping.

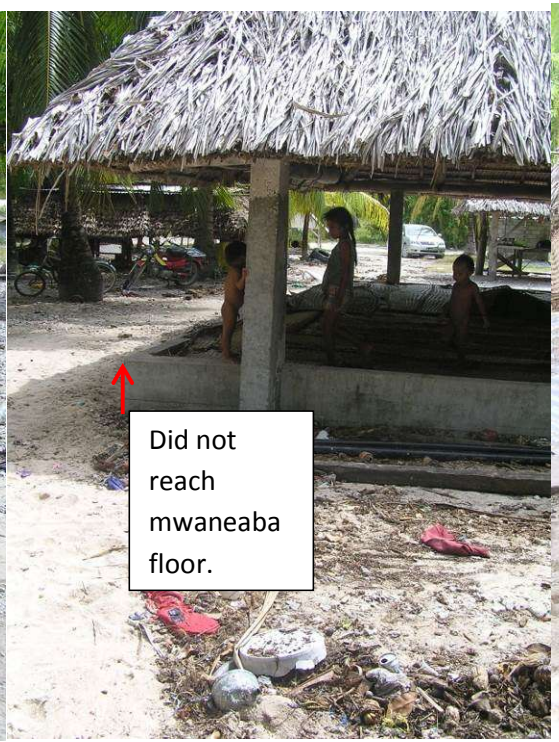

Water came in quick flooding approx. 45 cm high.

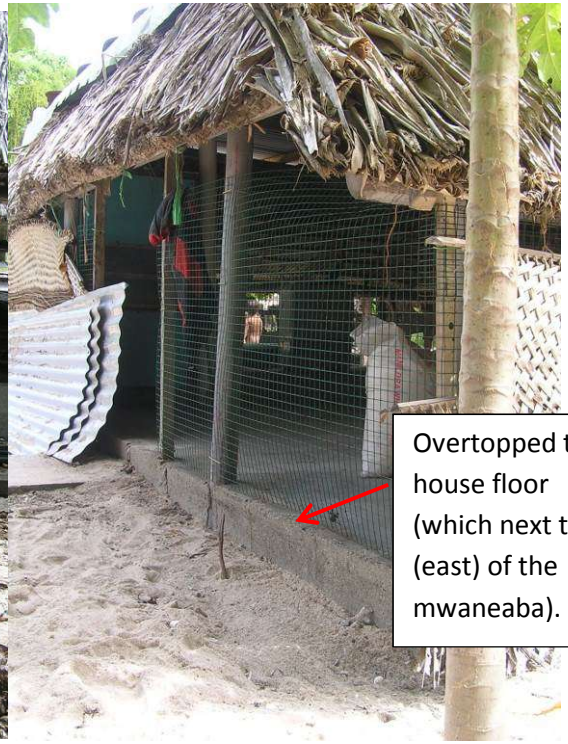

Flow marks.


House in previous pictures around the corner here.
Lagoon
Did not go above mwaneaba floor here.
Water entered open

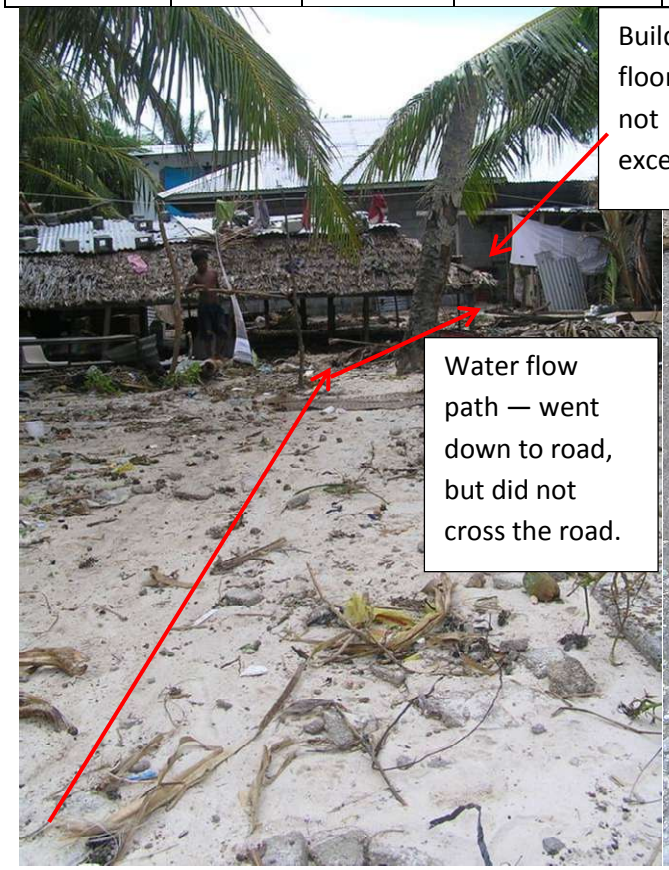

Affected breadfruit.
Flow path.

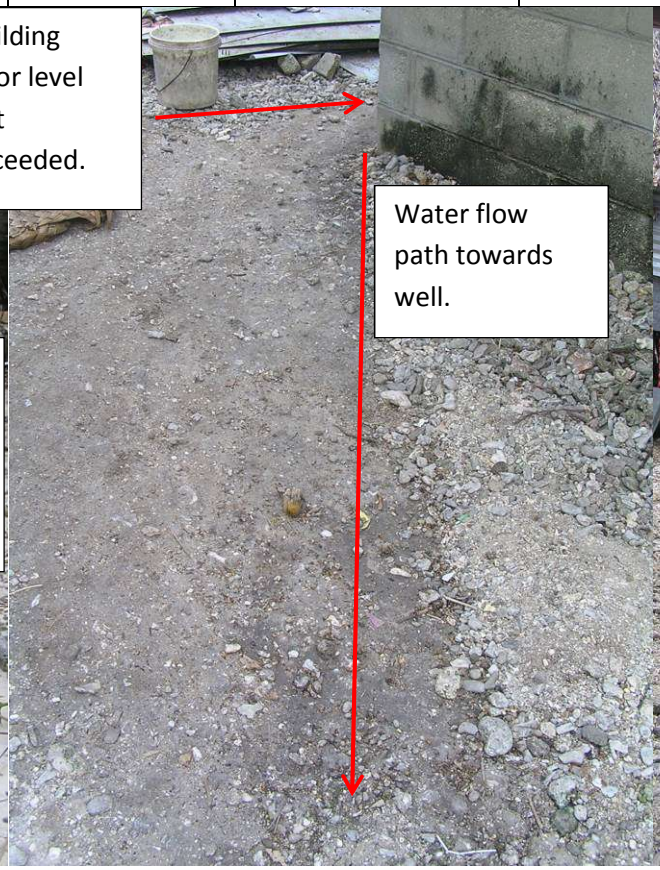
Household name	Village name	Lagoon/ Ocean	GPS coordinates	Max. distance the water came onto the land	Run-up (height above normal level)	Inundation event description
Tiataren (IN 6)	Kawai ae e boou	Ocean	N01 23 21.2, E173 08 30.1	up to the road	approx. 20 cm (under the knees)	During days of king tides, Tiataren discussed that on Monday afternoon and Tuesday morning around 05:00 a.m. the area was badly inundated compared with Saturday (1/04/14). On Monday and Tuesday the water ran up onto the road at a height of just under the knees. Tiateren's neighbour mentioned that inundation was happening once a year. Their house was flooded because the floor is lower (approximately 10 cm above the ground). Drinking well water is brackish from this incident.

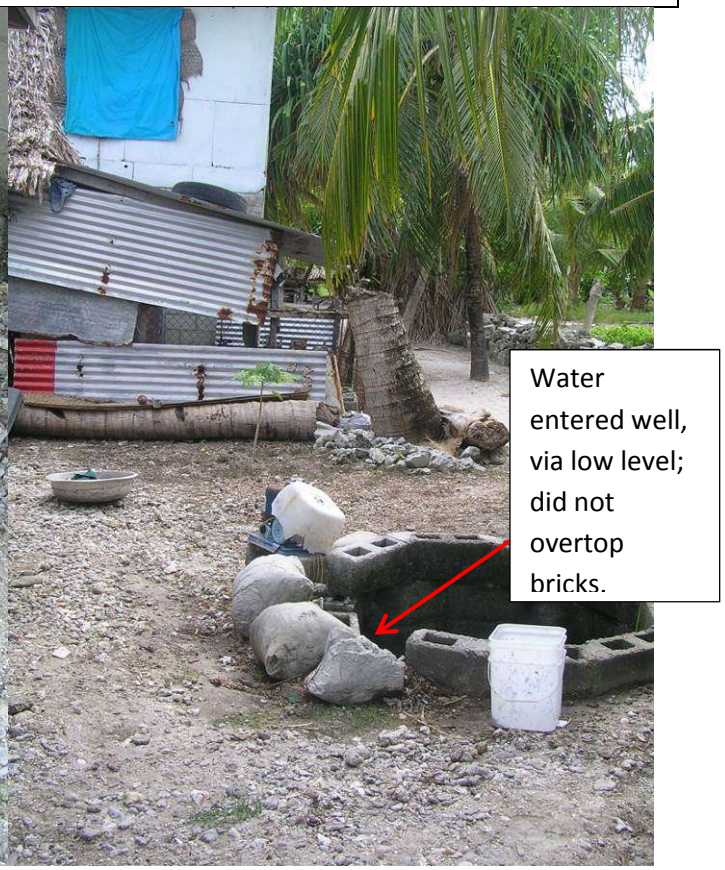




Household name	Village name	Lagoon /Ocean	GPS coordinates	Max. distance the water came onto the land	Run-up (height above normal level)	Inundation event description
Momo (IN 7)	Kawai ae e boou	Ocean	N01 23 14.1, E173 08 48.3	up to the road	15 cm	The area was badly inundated on Monday afternoon compared with Saturday, which enabled members of this household to evacuate to their neighbour's house. The water reached the oceanside of the road but did not cross the road. This house is opposite BN1.







Household name	Village name	Lagoon /Ocean	GPS coordinates	Max. distance the water came onto the land	Run-up (height above normal level)	Inundation event description
Bita (IN 8) - This house is where the machine installed	Kawai ae e boou	Ocean	N01 23 10.8, E173 08 53.3	12 steps	approx. 10	She reported that the inundation was worse on Monday afternoon. The water came to the house but not over the floor.

Appendix F: Booklet teaching resources for school water science activities

Water Science Teaching Resources

Materials and handbook for application at Bareaumai Primary School for Bonriki Inundation Vulnerability Assessment Project

1 March 2013

BIVA
BONRIKI INUNDATION VULNERABILITY ASSESSMENT

Australian Aid

TABLE OF CONTENTS

Water Teaching Tools

Understanding Groundwater – Building a model aquifer

Supplies needed for activity:

- Water
- Clear plastic container – rectangular or square with flat bottom preferable
- Gravel and sand
- Pin
- **Ruler/measuring tape**
- **Straws**
- **Whiteboard marker pen to draw water level changes**
- **Spray bottle**
- **Syringe**

1. Aquifer Construction

CONSTRUCT AQUIFER

1) **Take two straws and make holes in the bottom half with a pin, to allow water to flow into the sides.**
(Anai 2 te kai n totom ao kabwangabwangai n te pin ni karokoa e boo iterana)

2) **Tape one straw to the inside of the container at opposite ends. Make sure the straw is close to the bottom of the container and extends above the top. Tape multiple straws together for extra length. (Kanimwa teuana te kai n totom ma konan te kaonteina. Uringa ae e na riai te kai n totom anne ni kaan ma kabin te kaonteina ao ena riai ni bane anauna nako eta)**

8) **Pour a layer of gravel 5-10 cm thick (depending on the depth of your container) into the clear plastic container and spread out evenly. (Kabwaroa te atama ao kamaenakoa n te maten ae e nakon 5-10cm inanon te kaonteina)**

9) **Pour a layer of sand, approximately 5-10 cm thick (depending on the depth of your container) onto the gravel, then spread out evenly. (Manga Kabwaroa te tano iaon te atama ao kamaenako, kabaroa ni karokoa ae 5-10cm matenna)**

Water Teaching Tools

5) **Adding more gravel until the container is ¾ full. (Manga kabwaroa riki te atama iaon te tano ni karokoa ae 3/4 te kaonteina)**

6) **Lump up some gravel to represent mountains and insert leaves or twigs to represent vegetation. (Boboto te atama n te koona ni kateia kanga te maunga ao kabwai banikai iaona)**

7) **Take a jug and mix blue food colouring with water - this represents freshwater. (Kabwaroa te ran inanon te kaonteina)**

Learning objective

Learn how an aquifer is formed with different soil and geology.

This is the first step for the activities that follow to demonstrate how a groundwater aquifer is formed. This activity can be done using a larger square container as a demonstration, and individual class members can construct their own aquifer

EXTENSION: Add different layers to your model by using different materials (gravel, sand, soil, clay, etc.) Include a confined aquifer or confining layer to the model. Experiment with different materials such as sand, or foil to create bottoms of the surface water bodies in the model.

KEYWORDS: Aquifer, Geology

Water Teaching Tools

Water Teaching Tools

2. Water Cycle

WATER CYCLE DEMONSTRATION

1) **Fill the spray bottle or a cup with holes at the bottom, with coloured water. Spray the surface of your model to represent rain.(Kanoa te batoro ke te mangko ae e kabwangabwangaki aana n te ran ae iai karana. Kabwaroa iaon te atama bwa aongkoa te karau)**

2) **Continue to add water to the container with a cup or spray bottle until it is half full. (Teimatoa kabwaroa am ran ni karokoa ae e a boo iteran te kontaina)**

3) **Get students to mark with the pen the water table level. (Tuagia ataei ba ana makena tokin te ran ma ieta)**

4) **Ask them to measure the depth of the water table. (Manga tuagia ba ana anaa nanon te ran are inanon te kaoteina)**

Learning objective

Learn about the water cycle

DISCUSSION NOTES:

Demonstrate how groundwater is a part of the water cycle. As water is poured onto the surface notice how:

- *runoff forms streams or rivers on the surface*
- *pools of water form puddles or surface water*
- *the water infiltrates down into the gravel*

Discuss how evaporation and transpiration occurs from vegetation

KEYWORDS:

Water Cycle, Surface Water, Evaporation, Condensation, Rainfall, Runoff, Recharge, Groundwater, Aquifer, Water table

Other Teaching Materials

Other materials that can be used for this activity include:

- Poster on the water cycle

- Transpiration experiment (KAPII)

3. Groundwater and Surface Water

GROUNDWATER AND SURFACE WATER

1) **Scoop gravel from the edge of the container, digging down to the water table. Push the gravel to the sides of the container allowing the water to create a pool of surface water. (Kena te atama are inanon te kaoteina ni karokoa e roko n te ran. Kamwawa te atama nako iteran te kaoteina ba e aoria n reke ba kanga te karawarawa)**

2) **Slowly add more water, pouring the water on the gravel close to the sides of the container. Again watch how the water percolates down through the gravel and becomes groundwater. This time also observe what happens to the elevation of the surface water. (Karaurau ni manga kabaroa riki te ran ni konan te kaoteina iaon te atama ao kamataua raoi taran aron baraon te ran anne ni karokoa e roko ni kabin te kaoteina)**
3) **Get students to mark with the pen the new water table level. Ask them to measure the depth of the water table. (Butia ataei ba ana manga makena tokin te ran ma ieta ao n anaa nanon te ran anne)**
4) **Add water directly to the pool of surface water (babai pit/fish pond/lagoon/ocean). Watch the water table level. The water in the babai pit/fish pond/lagoon is recharging the aquifer, causing the water table to rise. (Manga kabwaroa te ran nakon aon te neinei are inanon te kaoteina)**
5) **Get students to mark with the pen the new water table level. Ask them to measure the depth of the water table. (Butia ataei ba ana manga makena tokin te ran ma ieta ao n ana nanona nako kabin te kaoteina)**
6) **Use a cup/ the spray bottle/syringe to remove water from the pool. This represents low tide and the change to the water level.**
   (Kabongana te ran ni kanakoa te ran mai inanon te kaonteina)
7) **Get students to mark with the pen the new water table level. Ask them to measure the**

depth of the water table. (Butia ataei ba ana manga makena tokin te ran ma i eta ao n anaa nanon te ran man kabin te kaoteina)

Qn:

What do you think happens to the fresh groundwater if the water coming in is salty? (Tera ae e na riki nakon te ran are ian tano ngkana e a roko taari iai?)

Learning objective (GROUNDWATER AND SURFACE WATER)

Learn how groundwater and surface water interact and how the water table level changes with inputs from surface water (e.g. sea level rise and tidal influence)

EXTENSION: Experiment with different materials such as sand, or foil to create bottoms of the surface water bodies in the model. Notice how this changes the influence of the change in water level in the water body and the groundwater table

DISCUSSION NOTES:

The pool of water formed could represent a pond in the middle of the land e.g. babai pit/fish pond. The pool could also represent the sea water in the lagoon or ocean side.

Step 16 and 18 could represent sea level rise, this could be from climate change or the daily change in tides.

Make note of how the water table changes when water is added to the land surface and the water surface – they are connected.

KEYWORDS:

Discharge, Surface Water, Tide

Water Teaching Tools
Water Teaching Tools

Understanding Groundwater – Pumping the Supply: Is groundwater a renewable resource?

Supplies needed for activity:

This activity continues on from the "Understanding Groundwater – Building a model aquifer"

4. Pumping Groundwater

PUMPING GROUNDWATER

1) **Pump the water out from the container with a well and make sure to catch the pumping water with plastic cup. (Bamia te ran ni kaotinako ao uringa ni butimaea te ran anne n te mangko)**
2) **Keep pumping the water for about 5mins and observe What happens to the water level in the container. (Teimatoa bwaam inanon 5 te miniti, Taraia raoi ba tera ae e riki nakon te ran are n te kaoteina)**
3) **Repeat step 1, While one student should add water using spray/cup at the same time. Observe What happens to the water level in the container. (Manga kaoka riki are karaoki n step 1, ao temanna te ataei e riai ni kabaroa te ran inanon te kaoteina n te tai naba anne. Karaua tara raoi ba tera ae e riki nakon te ran are inanon te kaoteina)**
4) **Discuss the sustainable yield.**

Qn. What pumping happens in Bonriki

Other teaching material:

Over pumping from wells poster and Sustainable use of freshwater

Learning objective

- To understand What happens if excess water are taken out from one point without recharge
- To understand What happens if water keep pumping and recharge at the same time.
- To understand water conservation

Discussion notes:

Well represents a straw. In step 3 adding water to the container can represent a recharge e.g rain.

EXTENSION: Rebuild the aquifer and include a confining layer. How does a confined aquifer respond to drawdown and recharge? Demonstrate the effects of pumping wells at various depths. Research and demonstrate factors affecting well location due to water quality concerns. Rebuild the aquifer with sand or a mixture of sand and gravel. Does the ma- terial the aquifer is made of affect the recharge and pumping rates? Demonstrate and explain a cone of depression. This is best demonstrated in sand.

KEYWORDS: sustainable yield

Water Teaching Tools

Understanding Groundwater – Groundwater and contamination

Supplies needed for activity:

This activity continues on from the "Understanding Groundwater – Building a model aquifer"

5. Groundwater Contamination

GROUNDWATER CONTAMINATION

8) **Fill a small measuring cup with water. (Kanoa te mangko n te ran)**
9) **Add 2-4 drops of red food dye to the cup of water. This colored water will represent contamination. (Kabwaka 2-4 te tim te ran ae e kara inanon te kaoteina)**
10) **In one of the corners of the model slowly pour the entire cup of contamination. (Kabwaroa te ran ae e bareka ni konan te kaoteina)**

11) **Observe the contaminant as it infiltrates the groundwater. Can you see the water flow path? (Taraia raoi ba e kanga aron butin te ran are e bareka anne)**
12) **Pump water from the straw (which represents the well) at the end away from the contamination using a syringe or spray bottle. Watch the surface water as the well is being pumped. Notice the color of the water that is pumped from this well. Collect the pumped water in a separate container. (Kamanena te kai**

Learning objective

To learn about how pollution on the land surface can impact the groundwater below.

DISCUSSION NOTES:

- *How can this contamination affect humans and the environment?*
- *What sources of contamination are there in Bonriki? Discuss how land use impacts groundwater quality.*
- *The contamination could also represent salt water from inundation from the sea. What happens to the fresh groundwater if salt water comes over the land surface?*
- *With multiple wells this demonstrates how the contamination travels across different distances. Compare the colour of the water pumped from different wells depending on the*

EXTENSION: Research and demonstrate factors affecting well location due to water quality concerns.

KEYWORDS:Contamination/Pollution, Inundation, Landuse

Water Teaching Tools

ni mooi ao te iti ke te tiburei ni bwamia te ran man te tabo are e raroa ma te tabo are e rotaki ke ni bareka. Kamwataua taran te ran ane inanon te kaoteina anne bwa tera ae riki nako iai inanon tain te bwam. Taraia naba ba tera ae e riki nakon te ran are e bareka.)

13) **Pump water from the straw closest to the contamination. Notice the color of the water pumped from this well. How does the colour compare with the water from the other well?(Manga bwamia riki te ran ni kania te tabo are e bareka ao kamataua raoi ba tera ae e riki nakon te ran anne)**

Other Teaching Materials/Activities

Other materials that can be used for this activity include:

- Water Lens Protection Bingo
- Worksheets/quizzes on land use

Water Teaching Tools

Understanding Groundwater -PUB Infiltration Galleries Systems

Supplies needed for activity:

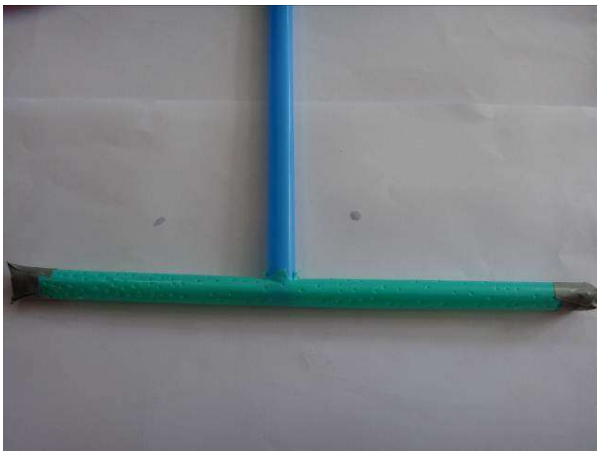
- **Water**
- **Clear plastic container or glass bowl**
- **Strong cordial (e.g. Sunquick) or equivalent sugary mix with food colouring**
- Ruler/measuring tape
- Straws
- Marker pen to draw water level changes
- Syringe

Activity

6. Infiltration Galleries

INFILTRATION GALLERY DEMONSTRATION

1) **Take 1 straw and cut a hole in the middle on one side so that another straw can fit into it to form a T shape. (Anaa teuana te kai ni moi ao kabangabanga nukana n te aro ba ena kona n rin iai te kai ni moi riki teuana ao n aron teina ane e oti n te tamnei are e oti inano.)**



2) **Using the pin put a lot of small holes into the straw that forms the top of the T (the horizontal straw). Use sticky tap to cover the ends of the straw and ensure the two straws are well connected/sealed. The T shape represents the infiltration gallery pipes.(Anaa te pin ao manga kabwangabwanga am kai ni moi are e wene i nano. Kabongana te tape ni bonota tabon am kai ni moi are e wene i nano, ko**

Learning objective

To understand the interaction of salt water and freshwater and the formation of the freshwater lens in a coral atoll

- T-shape represent water galleries
- Syringe represents the pump

Water Teaching Tools

kona n nora te tamnei are e oti i eta)

3) **Pour a thick layer (approx. 3cm) of pure cordial into the container – this represents the salt water (Kabongana te te sunquick bwain renganan te mooi ni kabwaroa inanon te kaoteina)**

4) **Using the syringe/Jar slowly add clean freshwater into the bowl, until it is almost full, add to the side so as to minimize disturbing the cordial layer (Manga kabwaroa te ran iaon te cordial ni karauraua n te aro ba e na aki irengan te ran ma te cordial are inanon te kaoteina. Kabwaroa ni karokoa ae e a kan on te kaoteina.)**

5) Put the T-Shape inside the container and starts pump water out using the spray and make sure to collect the outlet water. Observe What happens to the two layers inside the container. (Kanimwa te kai ni moi are tein T inanon te kaoteina ao bwamia te ran ni kaotinakoa ni kamanena te spray ao uringa ni bubutimaea te ran are e otinako inanon te tai ni bwam. Taraia raoi bwa tera ae e riki nakon te naan layers ake a uoua)

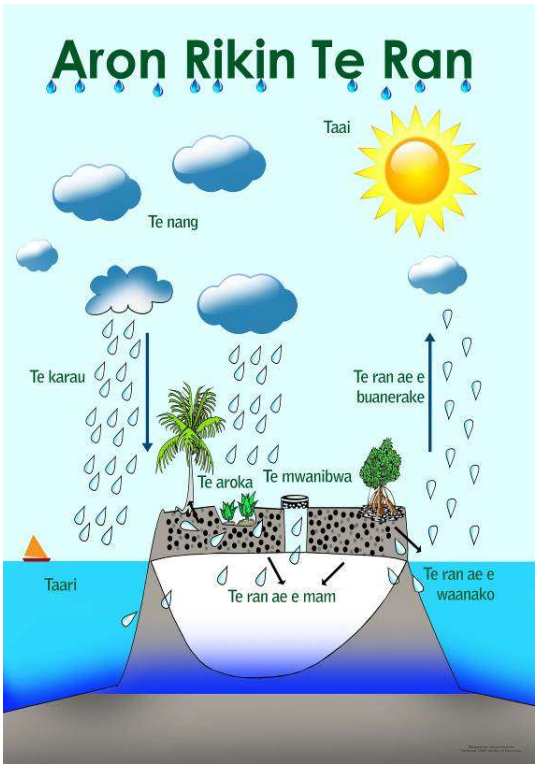
Other Teaching Materials/Activities

Other materials that can be used for this activity include:

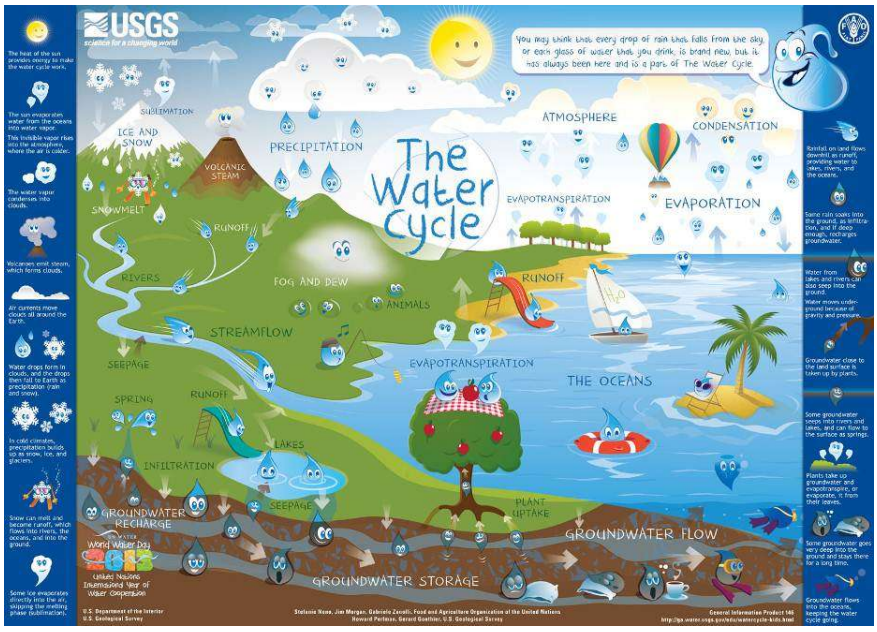
- **KAPII diagrams of pumping**
- **Well Survey – using WEU EC meters to understand the salinity of the water lens**
- **Mixing freshwater and salt water to measure different salinities**
- **Field trip to WEU and PUB sites in Bonriki**

7. Teaching Appendices

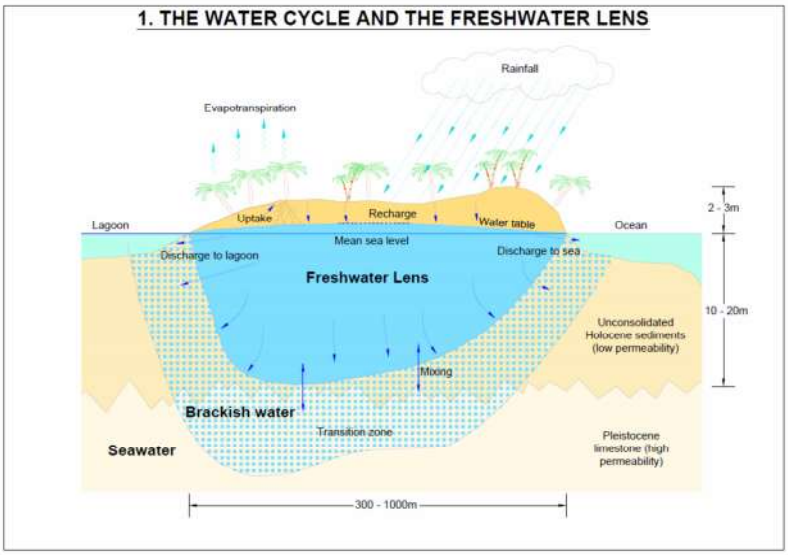
A. Water Cycle for Bareaumai Class 3 Students



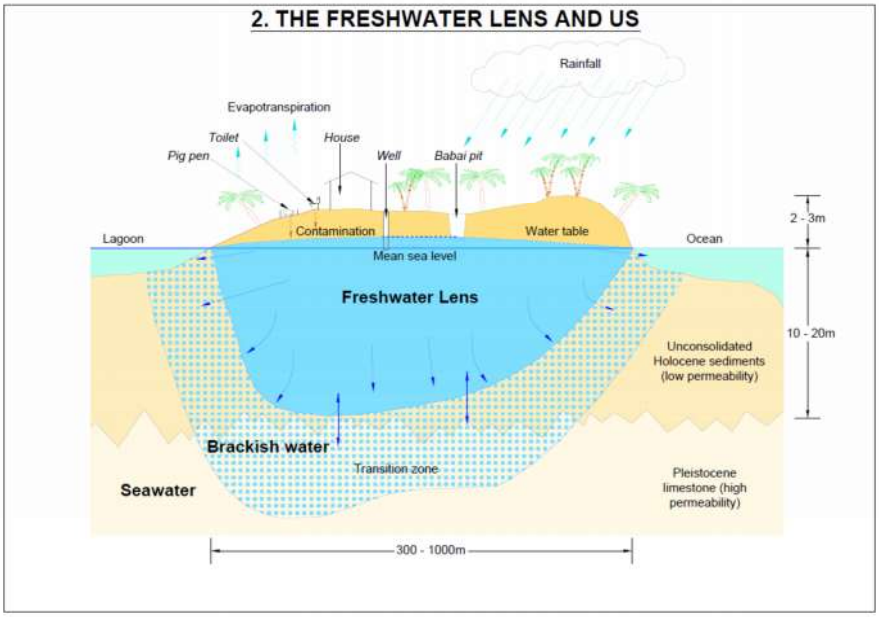
B. Water Cycle for KGV&EBS Form 5 Arts



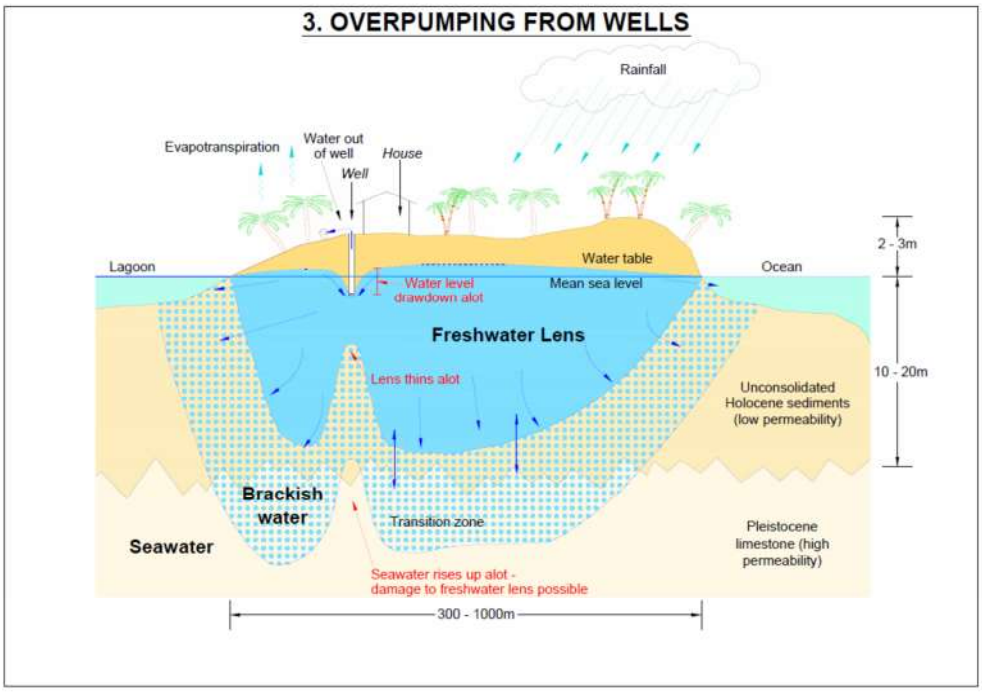
C. Water cycle and Freshwater for KGV&EBS Students



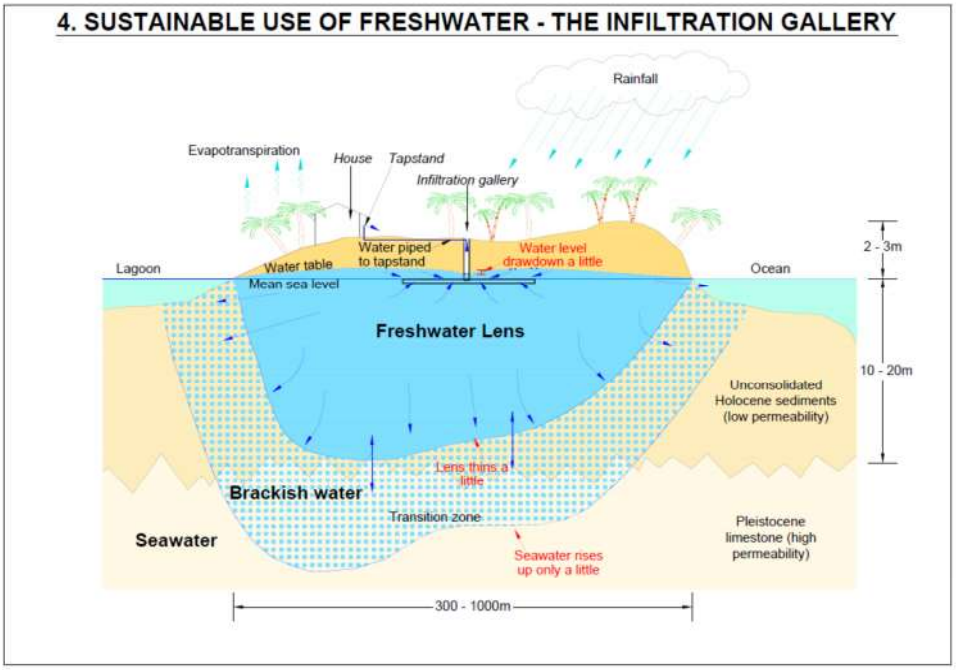
D. Freshwater and Us



E. Overpumping of Groundwater



F. Infiltration Galleries



8. Bingo Games Rules

'Water Lens Protection Educational Bingo'

The Bingo can be played with a large group of people of all ages.

Facilitator instructions:

1. Inform about the water lens, how it gets contaminated and what can be done to avoid contamination. Please see *Unit 4 Water Pollution and Protection, Water Committee Training Module 3: Water and Health Awareness*

2. Divide the participants into five smaller groups and divide one set of cards amongst the participants in every group. Ask them to place the cards in front of themselves so that the pictures are all visible. One set of game cards (black and white) is for the facilitator.

3. Then it is like normal bingo. The facilitator randomly picks one card at a time and calls out the name of the activity, animal or construction. If the participants have the card, they take it away.

4. The facilitator keeps on calling until the first person in the group has no more cards visible and calls out Bingo! Give out some candy to the winners.

5. For the next step place the picture of the water lens in the middle of the group and explain to the group what it is.

6. The group then has to place their cards they have been given inside or outside of the water area depending on whether they think it can have an impact on the water lens or not. Tell the participants not to look at the backside of the card.

7. When all the cards have been placed in all groups, all the people in the groups leave their board and move to the board of another group. The cards of the other group is turned over so that the 'yes' or 'no' sign can easily be read and then the number of right answers inside the protection zone are counted.

8. The group with the most correct answers wins the second round and receive some candy.

9. Then let the participants take turns in reading the backside of the cards out loud to the rest of the group so that the group learn about why the water is polluted and what can be done to avoid pollution. Encourage discussion amongst the participants.

10. Now ask every group to discuss which of the activities the Community/School should keep outside of the area. The facilitator should take notes of their answers.

G. Bingo Sheets

How does the water lens get polluted and how can it be avoided?

E kangara n reke ae buakaka te bwariko n Ran ao e na kanga aron tukana

By learning about how the water lens gets polluted you will notice that there are many actions that can be done in order to reduce water pollution from land activities.

Man reiakinan aron reken buakakaan te bwariko n ran ao kona bon ataia bwa ana rawata ara waaki ake tina mwakurii nte aro bwa e aonga ni kerikaki aron reken buakakan te ran man ara waaki ake ti karaoi ieta (aon te aba)

The following information includes animals, constructions and activities that are common in Kiribati and they may or may not have an impact on the water lens. This information can be used to set up rules about what should be allowed/not allowed around water collection areas in order to kept the freshwater clean.

Rongorong aikai n aiaroia maan, te naan kateitei ao waaki ni mwakuri ake ea bon tataneiai te aba iai n abara aei e na bon konaa ke e naki kona ni iai mwina nakon te bwariko n ran. Te rongorongo aei are e na bon kona ni kabonganaki ibukin katean tuua ibukina bwa e na kariaiakaki/ke n aki kariaiakaki ni katobibia te tabo n anai ran nte aro bwa e na teimatoa aron raoiroin te ran.

Te mwanibwa ae akea oona

Unprotected open well

Does it pollute the water lens? **Yes**

Open wells make the water lens vulnerable to contamination from land activities. Flooding can pollute an unprotected open well during heavy rain or storms.

Te mwanibwa aeakea oona

E kabuakaka te bwariko n ran? **Eng**

Mwanibwa aika akea ooia ana bon kai reke buakakan rania n tain korakoran bwakan te karau ke ni korakoran buakan te bong.

Te mwaniba ae e oaki

Partly protected open well

Does it pollute the water lens? **Yes**

Open wells make the water lens vulnerable to contamination from land activities. This type of well partly protects the water but a lid would reduce evaporation and protect from pollution better.

Te mwaniba ae e oaki

E kabuakaka te bwariko n ran? **Eng**

Mwaniba aika akea ooia ana bon kai buakaka rania man mwakuri ake a karaoaki ieta (aon te aba)Te aeka ni mwaniba aei e bon raa tau aron kawakinan te ran iai ma e na bon raoiroi riki ngke bon iai matana ke bonotana ike e na kona ni kamanoa te ran man buanerakena ao man kamanoa naba te ran man bwaai aika buakaka.

Open well with electric pump

Does it pollute the water lens? **Yes**

Regular electric pumps can be very damaging to the water lens in Kiribati and must be avoided. The can damage the water lens by making it salty for decades of pumped intensely.

Te mwaniba ae e aki ooaki ao man maeu mwina man te iti

E kabuakaka te bwariko n ran? **Eng**

Te naan bwam ake a maeu man te iti ana bon kona ni kabuakaka te bwariko n ran i Kiribati ngaia are ana bon riai n aki kabonganaki. Ana bon karekea te kanganga nakon te bwariko n ran nte aro are e na tarika iai te ran ngkana e a ribonobono aron kamanenakina

Partly protected well with electric pump

Is it vulnerable to pollution? **Yes**

Regular electric pumps can be very damaging to the water lens in Kiribati and must be avoided. The can damage the water lens by making it salty for decades of pumped intensely. A covered well is better than an open well.

Te mwaniba ae raatau oona ma bwamna te iti

E kabuakaka te bwariko n ran? **Eng**

Protected open well

Does it pollute the water lens? **Yes/No**

Properly protected wells may or

	may not have an impact on the water quality depending on if the area around the well and the bucket is kept clean. E kabuakaka te bwariko n ran? **Eng/Tiaki** Mwaniba aika a ooaki raoi ke ni kamanoaki raoi ana bon kona ke n aki kona ni iai mwia nakon raoiroin te ran, rekereken aikai ma tararuan raoi ao kaitiakan raoi te tabo ni katobibia te mwaniba ao bon itiakin naba te roa ke te bwakeiti ibukin te itiran.
	**Protected closed well with hand pump** Does it pollute the water lens? **No** Protected wells with a manual pump will not have a significant impact on the quality of the water but it is still important to keep the area around the pump clean. **Te mwanibwa ae bono raoi man ooki raoi ao mani kabongana te bwam are nte bai** E kabuakaka te bwariko n ran?

	E aki Mwanibwa ake a kamanoaki raoi ao n ooaki ao man kabongana te bwam ae tiaki te iti, e na bon aki buakaka ranna ma e boni kakawaki bwa e na kamatoaki aron itiakin te tabo ni bwam ni katotobia
	**Water Infiltration Gallery** Does it pollute the water lens? **No** The idea of infiltration galleries is that they should be placed in the middle of an island where there are no houses and where it can be protected from pollution. If people activities are kept outside of a water protection area around the gallery then the water should be clean. It is also designed to protect from saltwater intrusion.
	**Growing bwabwai** Does it pollute the water lens? **Yes** The cultivation of bwabwai with fertilizers such as pig manure and compost pollute the water with e-coli and nitrates. The open pits also make the water lens

	vulnerable to other forms of contamination and evaporation. **Unikan te bwabwai** E kabuakaka te ran? **Eng** Unikan te bwabwai ma kamwarakeana ke mauboniakina ni butaen te beeki ao te kaiao a boni kabuakaka te ran ni ikotaki ma te e-coli ao te nitrates. Te naa n rua a bon kai kabuakaka te bwariko n ran nte aro are a uki ao man kai rotaki ni bwaai aika a buakaka ake ana kona ni bwaka nako nanon te rua ao man irianaki ni buaneraken te ran
	**Bush toileting** Does it pollute the water lens? **Yes** The product of toileting is a health hazard and it pollutes the water lens. The activity of toileting should be kept away from the water collection area. It is better to do toileting in the ocean or in a hole in the sand on the beach slope that you can cover up to protect from flies that spread diseases. **Te beka nte buakonikai**

	E kabuakaka te ran? **Eng** Te nakotari / te nakotinaniku e bon karekea te aoraki ao e kamwaraea nab ate bwariko n ran.Te mwakuri n nakotarii / ni beka e bon riai ni kakiraroaki karaoana man te tabo n ran. E raoiroi te nakotari i tari ke kena nnnen te nakotari iaon karabeen te bike nako taari are e na kona ni manga taunaki man raba mai irouia naango bwa a rawa ni manga kabuta te aoraki
	**Septic tanks** Does it pollute the water lens? **Yes** Leaking septic tanks have been identified to be the most common source of water lens pollution. It is therefore very important to maintain and empty pit latrines regularly. If possible, they should be kept at least 30 meters away from any water collection area **Mwarua ni kain nakotaari** E kabuakaka te bwariko n ran? **Eng** Mwarua n nakotaari aika a raran a bon tia n ataaki bwa ngaia aika

	aki toki ni kabuakaka te bwariko n ran. E kakawaki bwa e na kateimatoaki aron kanakoan te bwai are inanona ni katoatai. Ngkana ngaia ao a riai ni kakiraroaki mwarua n nakotaari tao 30 te miita raroana man te tabo n ran.
	**Graves** Does it pollute the water lens? **Yes** Graves should be kept far away from water collection areas as decomposing bodies pollute the water. **Te ruani mate** E kabuakaka te bwariko n ran? **Eng** Rua ni mate a bon riai kakiraroakia man te tabo n ran bwa rabwataia maate ake a moana buakakaia boni ngaia aika ana kamwaraea te ran.

	**Pig pens** Does it pollute the water lens? **Yes** Pig pens need to be kept far away from water collection areas and preferably towards the edge of the island. The pigs pollute the water lens with their feaces. **Te ooni beeki** E kabuakaka te bwariko n ran? **Eng** Oonibeeki a bon riai kakiraroakia man te tabo n ran ao man raoiroi kamenakia ni mangengen te aba. Beeki a bon kabuakaka te bwariko n ran n nakotaria

Te beeki

Pigs

Does it pollute the water lens?
Yes

It is recommended to keep free roaming pigs far away from water collection areas as pig faeces will pollute the water lens. Pig faeces are particularly bad.

Te beeki

E kabuakaka te bwariko n ran?
Eng

Ana bon riai ni kaiwaeaki beeki ni kakiraroaki ma te tabo n ran bwa are nakotariia beeki ana bon kabuakaka te ran

Te kamea

Dogs

Does it pollute the water lens?
Yes

It is recommended to stop dogs from getting close to water collection points as their feces pollute the water.

Te kamea

E kabuakaka te bwariko n ran?
Eng

A bon riai n tuukaki kamea man aki kania te naa n tabo n ran ba are nakotaria a bon kabuakaka naba te ran

Te moa

Chickens

Does it pollute the water lens?
Yes

If possible it is good to prevent chickens from getting close to water collection areas as the faeces pollute the water.

Te moa

E kabuakaka te bwariko n ran?
Eng

Ana tukaki naba moa man kaniakakin taabo n ran ngkai ana bon kabuakaka naba te ran n nakotaria.

Te maange

Rubbish disposal/

Does it pollute the water lens?
Yes

Plastics and food leftovers should be kept far away from water collection points it may leach in to the water lens when it breaks down. Rubbish should preferably be sorted out.

- Organic waste such as leaves can be used for composting in gardens
- Reusable items such as PET bottles and glass can be reused to serve other purposes. Rusty tins can be used in gardens.
- Inorganic wastes such as plastic wrappings should be kept far away from any water collection area.
-

Karenakoan te maange

E kabuakaka te bwariko n ran?
Eng

Tenan plastics ao nikiran amwarake a bon riai ni kakiraroaki man taabo n ran. Ana kona n roronako nte tano ao man roko nte bwariko n ran ni kabuakaka. Maange a bon riai baireakia raoi nakon teia nako

- Mka ni kai ke baanikai a bon kona ni kabonganaki bwa te

	kaiao nakon te aroka • Bwaai aika a kona ni manga kabongaanaki n aron te naan bwator (PET) ao ake a kirati a kona ni kabonganaki n anga tabeaua. Tin aika a rara a kona ni kamaneraki nte oonaroka bwa kanan te aroka. • Maange aika aki kona ni mka n aron plastics a bon riai kamenakia ni kakiraroaki ma te tabo n ran.
Kimbi 	**Disposing diapers** Does it pollute the water lens? **Yes** Baby faeces is a health hazard and the chemicals in the plastic is also bad for the water quality. Diapers should be burnt in small quantities or disposed off far away from a water collection point. Do not dispose diapers in the sea since it contains plastic that can cause choking to marine life such as turtles and fish. Encourage the use of cloth nappies that can be cleaned. **Karenakoan te kimbi** E kabuakaka te bwariko n ran? **Eng**

	Nakotaaria ataei e buakaka nakon marurungira ao te kemiko (chemical – bwaai aika a kona ni boitin ngkana a kabonganaki n ae e mwaiti) nte buraetiki (plastic) ni kimbi e bon kabuakaka naba te ran. Tenan kimbi a bon riai ni kabuekaki nte mwaiti ae uarereke ke nuotakinako nakon te tabo ae e raroanako ma te tabo n ran. Tai karenakoi kimbi i taari bwa a rawa ni mate manin taari/ika/te on ao a mwaiti riki ni bono ikeia ni buraetikin kimbi. Kaunga kabonganaan te bitake te kunikai bwa e bon raoiroi nakon tetei ao a kai uatiakaki ni kaitiakaki n taai nako

	Medical Waste Does it pollute the water lens? **Yes** A special waste is a waste from medical treatment or testing such as for instance needles, syringes, vaccines, medicines, tablets etc. A recommended way to dispose of medical waste is by burning far away from water collection areas. **Mangen bwainaoraki** E kabuakaka te bwariko n ran? **Eng** Te maange ae kaokoro are bon maangeni bwainaoraki n airon karaoan maneka, ke neiran ma iti, bwaa ni iti, bwatin ao a mwaiti riki. A katauaki maangen bwainaoraki aikai bwa ana kabuekaki n taabo aika a raroa ma taabo n ran

Kamangeange

Car wreck

Does it pollute the water lens?
Yes

Old cars and motorbikes should be kept outside of the water area as they contain toxic metals that can leach into the water and it is very bad for both the health and the environment.

Car batteries are recyclable and should be returned to Kaokimaange.

Maangen te kaa

E kabuakaka te bwariko n ran?
Eng

Kaa aika mane ao rebwerebwe a riai ni kawakinaki n raroanako ma taabo n ran bwa a boitin ngkana a roronako rania nakon te bwariko n ran ao mani kaboitina te bwariko n ran are e bon buakaka nakon marurungira ao nakon ara otabwanin

Te oera/ bai n aoraki

Oils & Chemicals

Does it pollute the water lens?
Yes

Oil and chemicals are toxic and should be kept away from water collection areas. Oil contamination cannot be treated with boiling and the oil will accumulate in the digestive system and can cause cancers in the long term. Local communities advised to return oil waste to oil depots on the island for shipment to KOIL. If that is not possible then the recommended way to dispose of these products is to be burnt aware from any water area.

Te ooera & te kemikoro

E kabuakaka te bwariko n ran?
Eng

Te naan ooera ma kemikoro a bon rangi ni buakaka ao a riai ni kakiraroaki man tenaan tabo ni katiiran. Kabuakakan te ran man te ooera e bon aki kona n raoiroi e ngae ngkana e kaburoaki te ran. Ngkana e aki toki n nimaki te ran ae ooera inanon te tai ae maan ao e na bon kona ni karika te kantia nte kanoan nano. A riai n ataia aomata nako bwa a riai ni kaokii aia ooera ake a buakaka ke n tia ni kamanenaaki nakon taabo ni bwaa ibukin kaokaia nakon te KOIL Ngkana ea aki reke karaoan aei ao ariai ni kabuokaki maangen nako te ooera nte tabo ae raroanako ma te tabo n ran.

Tewenakoan taian baetere

Disposing of batteries

Does it pollute the water lens?
Yes

Batteries contain several toxic substances that can have effects to human health overtime when accumulated in the body. Children should be discouraged to play with old batteries. The best way to dispose of batteries is to place them in a contained manner away from children and away from any water collection area. There is no system yet to recycle batteries.

Tewenakoan taian baetere

E kabuakaka te bwariko n ran?
Eng

Te naan batere bon iai inanoia bwaai aika a buakaka are ana kona iai mwia aika aki raoiroi nakon te aomata nte tai ae maan ngkana ea titiku nte rabwata. Ataei a riai n aki kaungaaki n takakaro ma baetere. Te kawai ae raoiroi ibukin karenakoan

	baetere bon botakia nte bwai teuana ao mani kakiraroaki ma ataei ao man taabo n ran. E bon tuai reke moa aron manga kamanenakin baetere ake a tia ni kabonganaki.
 **Tobu nu uati**	**Dirty dish washing water** Does it pollute the water lens? **Yes** Dishes washed with soap bars is not so bad but if the dishwashing water contains detergent it should be discharged away from the water collection area. Preferrably towards the edge of the island (and away from wells), where there are bushes/trees that can use the water. **Ran n tebo raurau** E kabuakaka te bwariko n ran? **Eng** Bwain amwarake ake a kaitiakaki ma te tobu te kai a bon aki bati ni buakaka ma ngkana te ran n tobu iai iai bwaai n ai aron te bwai ni kaki memea ao e na bon kabwaroaki nte tabo ae raroa nako ma taabo n ran. Tao i tabon te aba n raroa nako ma tenan mwanibwa ike iai iai te buakonikai ma kaai aika abwabwaki ake a kona ni kamanena te ran n tobu ae buakaka aei.
 **N aekaia nako**	**Dirty clothes washing water** Does it pollute the water lens? **Yes** Washing powder pollutes the water lens with phosphate and nitrates and dirty water contain colour chemicals from the clothes that are not healthy. Cleaning of clothes soiled with feaces is particularly polluting. Washing water should therefore be discharged towards the edge of the island (and away from wells), where there are bushes/trees that can use the water. **Te ran toobu** E kabuakaka te bwariko n ran? **Eng** Te tobu te bubu ibukin te uati e bon kabuakaka te bwaro n ran ma bwaai aika tenan phosphate ao te nitrates ao te ran n tobu are ea barekareka bon iai iai tenan kemikoro ake a karanaki iai tenaan kunikai ao are a bon aki raoiroi nakon marurungira. Kaitiakan kunikai ake iai iai te nakotaari e bon rangi ni kabuakaka te ran. Ran nu uati ake a tia ni kabonganaki a bon riai ni kabwaroaki ni mangen te aba nte tabo ae raroa ma tenan mwanibwa ake iai iai te buakonikai ao bon kai aika a bwabwaki man bubura ake a kona ni kamanena te ran ae buakaka aei

	White King Does it pollute the water lens? **Yes/No** White King and other bleaching products with chlorine is good for killing some bad bacteria in the water but you have to be careful not to use too much. Bleaching products in larger quantities is not healthy for humans and can kill marine life. B**aini kaki memea** E kabuakaka te bwariko n ran? **Eng/E aki** Bwaai ni kaki memea are iai iai te kuroriin e raoiroi ibukin kamatean maan aoraki ake a mena nte ran ma kamanenaana nte mwaiti ae riao e bon aki raoiroi nakoira ao e kona naba ni kamatei manin taari n aekaia nako.

 **Te on-aroka**	**Growing vegetables** Does it pollute the water lens? **Yes** Vegetables such as cabbage are healthy as they contain a lot of good vitamins and minerals. However, the growing of vegetables should be kept away from the water area if fertilizer or compost is used to make them grow better. **Unikan te banikai ao uanikai** E kabuakaka te bwariko n ran? **Eng** Ua ni kai ma baanikai n aron te kabiti a bon bongana nakon te rabwata bwa are iai iai bwaai ake a raoiroi nakon te rabwata n aron tautian te rabwata. Unikan uanikai ma baanikai a riai ni kakiraroaki ma te tabo n ran ngkana arona bwa a kamanenaaki bwain aoraki ao kaiao nakoia ibukin ae ana maeureirei

Te anai atama/tano 	**Gravel & sand mining** Does it pollute the water lens? **Yes** The mining of gravel and sand increases erosion, results in thinning the water lens and makes it susceptible to any land based pollution. **Te anai tano ao atama** E kabuakaka te bwariko n ran? **Eng** Te anai atama ao te tano e bon karika kanakin te aba nte aro are ea kamania te bwariko n ran are inano ao mani karika kabuakakan te ran man bwaai ake a buakaka ake iaon te aba ngkana a roronako
 **Te auti/ Te maeka**	**Houses and living area** Does it pollute the water lens? **Yes** Many human every day activities can impact the the water quality so when possible it is good to keep houses away from water collection areas. **Te auti/te maeka /te**

	kateimaeka kabuakaka te bwariko n ran? **Eng** Ana mwakuri te aomata n aekaia nako ana bon iai mwia aika aka a buakaka nakon raoroin te ran ngaia are e bon raoiroi ngkana a raroanako taabo n ran ma auti ni maeka
	**Walking & playing** Does it pollute the water lens? **Yes/No** People accessing a water collection area occasionally for example when collecting water from a well, is not a problem but playing with or around a well or a pump should be strictly discouraged. **Te nakonako & takakaro** kabuakaka te bwariko n ran? **Eng/E aki** Mwanangaia aomata nakon taabo n ran ibukin karekean te ran bon tiaki te kanganga, ma te takakaro irarikina ke ni katobibia te mwanibwa ke te bwam e na

	bon aki kaungaki
	**Growing fruit** Does it pollute the water lens? **Yes/No** Growing fruit such as banana and pawpaw is not a big problem for the water quality but if fertilizer or compost is used to make them grow better or if they are grown in a pit, then they should be kept away from water collection areas. **Te ununiki** kabuakaka te bwariko n ran? **Eng /E aki** Unikan kain amwarake n aron te banana, ke te bwabwaia bon tiaki te kanganga nakon raoiroin te ran ma ngkana a mauboniaki ke ni bwainaorakiaki nte kaiao ke te bwauta ibukin kamaeureireian te aroka ke ngkana a unikaki nte mwarua ao ana bon riai ni kakiraroaki ma taabo n ran

	**Burning of land** Does it pollute the water lens? **Yes/No** Burning of land does not significantly pollute the water lens but native vegetation protects the fresh water lens and biodiversity from direct water evaporation from the sun. Vegetation also protect the land from erosion. Many people believe that burning of the land will make it more fertile but it is not true. **Te kabuebue n teaba** kabuakaka te bwariko n ran? **Eng /E aki** Kabuekakin te buakonikai e bon aki kabuakaka te bwariko n ran ma te buakonikai ke kain te aba a bon kamanoa te bwariko n ran ma te reitanimaeu man ana mwakuri riringan taai are e katika te ran ni waerake (te buane). Kain te aba ke te buakonikai a bon kamanoa te aba man kanakinako. Aia koaua aomata bwa kabuekan te buakonikai e na bon kamaeureireia te aba are e a tia ni kabuekakai kaina

Unikan te nii
Te tai ni boben

Planting coconut trees

Does it pollute the water lens? **No**

Planting coconuts will not impact the quality of water but it is recommended to keep coconut trees away from water collection points as one coconut tree drinks 150 litres of water per day (same as the water use of 3-5 people per day).

Unikan te ni

kabuakaka te bwariko n ran? **E aki**

Unikan te nii e na bon aki kabuakaka te ran ma e bon riai nu unikaki te nii ni kakiraroaki ma te tabo n ran ngkai teuana te nii e nima 150 te riita nte bongina(ai aron te mwaiti ae a kona ni kamanena 3-5 te aomata nte bongina)

Karaoan te takataka/oroben

Harvesting copra

Does it pollute the water lens? **No**

Harvesting of copra will not impact the quality of water but it is recommended to keep coconut trees away from water collection points as one coconut tree drinks 150 litres of water per day and thus reduce the fresh water lens thickness.

Oroben

kabuakaka te bwariko n ran? **E aki**

Te oroben bon akea buakakana nakon te bwariko n ran ma a bon riai ni kakiraroaki nii man taabo n ran ibukin are te kaina te nii e katika te ran ae 150 te riita nte bongina nte aro are ea kai mmani iai te bwariko n ran are inano

Te oka-tou/ unikan te kaina

Harvesting pandanus

Does it pollute the water lens? **No**

The pandanus fruit is healthy to eat as it is a good source of vitamin C and pandanus trees does not significantly impact the water quality.

Teoka-tou

kabuakaka te bwariko n ran? **E aki**

Te tou bon te uanikai ae raoiroi nte kanaki ngkai e bon reke mai iai tautian te rabwata ae vitamin C ao te aroka ae te kaina e bon aki kabuakaka te ran

Te okamai/unikan te mai

Harvesting breadfruit

Does it pollute the water lens? **No**

Growing breadfruit trees does not have a significant impact on the water quality.

Te okamai

kabuakaka te bwariko n ran? **E aki**

Unikan te mai bon akea mwina ae kabuakaka raoiroin te ran

Te bwai n aoraki ni Kiribati

Harvesting local medicine

Does it pollute the water lens? **No**

Generally, the trees that are used for local medicine can grow near water collection areas.

Te bwain aoraki ni Kiribati

kabuakaka te bwariko n ran? **E aki**

E bon ataaki bwa kaai ake a kabonganaki ibukin te bwainaoraki ni Kiribati a bon kona nu unikaki ni kaan ma taabo n ran

Te koro karewe 	**Cutting toddy** Does it pollute the water lens? **No** The cutting of toddy will not impact the quality of water but coconut trees drink 150 litres of water per day so it is better to grow the trees for toddy way from water collection area. **Te korokarewe** kabuakaka te bwariko n ran? **E aki** Te koro karewe bon akea mwina ae buakaka nakon raoiroin te ran ma are te kaina ten ii e nima 150 te riita te ran nte bongina ngaia are e raoiroi unikaia ni kakiraroaki ma taabo n ran
 **Te kinikaue**	**Picking flowers** Does it pollute the water lens? **No** Flowering trees make the surroundings look pretty and will not pollute the water.

	Te kinikaue kabuakaka te bwariko n ran? **E aki** Kaai aika a ue a bon katararaoa te tabo ao man aki kabuakaka te ran.

 **Te riko aia**	**Collecting firewood** Does it pollute the water lens? **No** Collecting firewood close to water collection areas is not a problem. **Te rikoaia** kabuakaka te bwariko n ran? **E aki** Te rikoaia n taabo n ran bon akea buakakaia.

Te tau mwanai

Collecting crabs

Does it pollute the water lens? **No**

Collecting crabs is not a problem but the bwabwai pits where some of the crabs live should be kept away from water collection areas.

Te taumwanai

kabuakaka te bwariko n ran? **E aki**

Te taumwanai bon tiaki te kanganga nakon te tabo n ran ma rua ni bwabwai ake a kona n reke iai mwanai a bon riai ni kakiraroaki ma taabo n ran

Te marae ni butiboro

Sport field

Does it pollute the water lens? **No**

A sporting field does not impact the quality of water and it is actually good to have close to the water area. In fact a minimal number of trees is good as it reduces the volume of fresh water consumed from the water lens. It may reduce the risk of toileting happening close to a water collection point.

Marae n takakaro

kabuakaka te bwariko n ran? **E aki**

Te marae n takakaro bon akea buakakana nakon raoiroin te ran ao e bon raoiroi ngkana e kaan ma te tabo n ran. Karakon kaai irarikin te tabo n ran e bon kauarerekea kamanenaan te ran ae mam man te bwariko n ran. E na bon kauarerekea naba aron te bwai ae na riki n aron te nakotari nu uakaan ma te tabo n ran.

H. Bingo Game Board

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